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LOCAL WARNING SYSTEM DEFINITION

by

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for

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ABSTRACT

This document is the final report of the Local Warning System Definition project performed for the Stanford Research Institute under Subcontract SRI 12675 (6300A-680). The report describes a method for determining an optimum mixture of public warning systems. Two types of input data to the optimum mixture method are developed: warning effectiveness standards based on empirically determined news dissemination rates and broadcasting industry audience figures, and measures of particular systems' coverage and speed of dissemination--or system effectiveness. In addition to two versions of the warning effectiveness standards, outdoor warning, EBS (crisis), EBS with CHAT-TV and a telephone warning system are used in a first test of the method. Use of the optimum mixture in programs for estimating increased survivors is also described.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Cont'd)

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

This report analyzes and measures selective aspects of public warning for the purpose of devising a means of determining the optimum mixture of equipment, systems, and techniques for indoor and outdoor alerting and warning. A major task was one of measuring total system effectiveness using the variables set by the contracting agency of population coverage and speed of dissemination. Our procedure was to (1) determine a standard level of warning performance; (2) obtain measures of warning effectiveness provided by the individual warning systems; and (3) evaluate these systems for their contributions to warning improvement and from these evaluations develop a schema for allocating resources for optimum warning systems.

However, some ancillary problems required solution before this procedure could be followed. First, it was necessary to obtain warning performance standards uncontaminated by data from the systems they are to evaluate. Using news source effectiveness rates (acquired from a variety of news diffusion studies), audience measures, and several assumptions regarding the composition of the media audience and nonaudience complement, it was possible to devise a basic news dissemination estimate for each medium considered. By applying the same rates and assumptions to hourly audience measures (normalized for time zone differences), similar estimates were prepared for each hour of the day. These findings are intended to approximate the dissemination of very important news throughout the population in the absence of a public warning system. The estimates served as the standards of effectiveness--standards which can be used to evaluate the effectiveness of any public warning system or mixture of systems.

Following this, it was necessary to determine the population distribution over the 24 hours of the day--at least for metropolitan areas. These estimates were

derived from a block-by-block analysis of land use maps of five American cities, and an earlier study of city population distributions in each of the main types of city areas. The resulting estimates were used in subsequent computations to analyze the effectiveness of selected local warning systems. These direct warning systems--outdoor signals, EBS, EBS/CHAT-TV, and telephone warning--were selected because of the availability of applicable data.

The last step in devising a method to determine an optimum mixture of warning systems was to identify procedures suitable to that task. The first set of procedures was quantitative and objective. That is, the effectiveness measures for each warning system were measured in terms of the range of warning coverages provided at 5-, 15- and 30-minute intervals; the average differences between systems; and the consistency of the observed differences. When these measures are made for each of the systems in contrast to the warning standards, some regular differences in potential warning improvements become apparent. However, these objective observations were tempered by subjective factors, and the differences in performance interpreted in a more reasoned fashion and a better judgment reached.

A second major task of the study was to provide a basis for estimating increased survivors attributable to the optimum mixture under differing attack conditions. The "basis" provided was essentially the system effectiveness data produced in the course of the study. However, since there are numerous models for estimating increased survivors attributable to different civil defense measures (most of which are in classified reports and use classified data and assumptions), this report describes the procedures for making the effectiveness data compatible with such models and provides an example with one unclassified model.

CONCLUSIONS

The principal conclusions reached in this study are:

1. Despite limitations in the assumptions used, the warning standards derived in this study are useful for comparing, evaluating and optimizing warning systems and for providing measures of population coverage and time.

2. When compared to the warning standards, the following observations were made for the systems being considered:

- The outdoor warning capability is slightly lower than that of the warning standards. The average number warned within 5-, 15-, and 30-minute intervals was estimated at 11 million, 54 million and 74 million, while the warning standards were estimated to warn an average 32 million, 44 million, 74 million in the same time intervals.

- Outdoor warning performs best during the 11 AM to 5 PM period when more people may be outdoors and the ambient noise level is lower.

- The population best served by outdoor warning is that fraction of the total population not immediately available to other information sources, e.g., radio, television, etc.

- Crisis EBS provides a clear and consistent improvement to the coverage provided by the warning standards in each of the intervals used. The average EBS improvement is 20 percent at 5 minutes, 24 percent at 15 minutes, and 14 percent at 30 minutes.

- While the advantage of crisis EBS is consistent, the system makes its smallest improvement and achieves its lowest coverage during the late night, early morning hours.

- EBS/CHAT-TV provides an equally consistent improvement in warning capability as EBS alone, with the added advantage of the improved coverage during the late night, early morning hours. These improvements yield an average increase in coverage of 30 percent at 5 minutes, 37 percent at 15 minutes, and 21 percent at 30 minutes for EBS/CHAT-TV.

- Telephone warning provides the capability of major improvements in warning effectiveness. The average increase is 128 percent at 5 minutes, 76 percent at 15 minutes, and 18 percent at 30 minutes.

- Telephone warning has the greatest potential during the 8 PM to 5 AM time period, when more of the population are at home and near telephones.

3. When the systems considered are compared to each other and to the warning standards, additional regularities are observed:

- The rank order for coverage ranges of all systems considered was: telephone, 1.5; EBS/CHAT-TV, 2.1; EBS, 2.6; and warning standards, 3.8.

- For metropolitan areas only, outdoor warning and the warning standards tie in rank order.

- The average hourly rank order for the systems was: telephone, 1.4; EBS/CHAT-TV, 2.1; EBS, 2.5; and the warning standards, 4.

- The metropolitan average hourly rank order put the warning standards ahead in the 1.4 position, followed by outdoor warning with 1.6.

4. The average hourly system contribution to total warning improvement was:

EBS	18 percent
EBS/CHAT-TV	27 percent
Telephone	55 percent

5. With only the systems considered in this study, the optimum mixture--and therefore the optimum allocation of resources--would be as noted above with the following exceptions:

- Apportion some resources to develop promising alternative systems, such as Decision Information Distribution System (DIDS), for a public warning capability.
- Continue maintenance allocations for outdoor warning until a near-perfect indoor and outdoor alerting and warning system is devised.

RECOMMENDATIONS

The following are the recommendations resulting from research performed on this contract:

1. Continued work on population distributions is required both to improve the quality of estimates and expand the area of coverage provided in this study. A special census or special data gathering, or both, may be necessary to adequately complete this task.

2. Special attention should be given to the dissemination of news during events comparable to crisis situations.

3. Data on the effectiveness of CHAT-TV and telephone warning are needed to confirm or modify the present assumptions.

4. The extremely short distribution time of DIDS makes expansion of its capability to include the public particularly attractive from a warning effectiveness standpoint. An effort toward that end should be considered in making an optimum mixture determination.

5. Since EBS and CHAT-TV are not intended to exist independently, some decision on the further development and implementation of CHAT-TV should be made so that subsequent assessments of EBS effectiveness can be made to include or exclude this capability.

INTRODUCTION

PURPOSE AND SCOPE

The purpose and scope of the work accomplished for this project is as specified under the provisions of Subcontract SRI 12675 (6300A-680), Article 1, Statement of Work, page 2, as follows:

"1. Develop methods for determining the optimum mixture of equipments, systems, and techniques for indoor and outdoor alerting and warning.

"2. Define total system effectiveness in terms of population coverage and speed of dissemination.

"3. Provide a basis for estimating increased survivors attributable to the optimum mixture under differing attack conditions.

"The study shall include but not be limited to a review and analysis of the effectiveness of various existing and proposed indoor and outdoor alerting and warning equipments, systems, and techniques, and of possible combinations of these to achieve various levels of effectiveness. In addition, the analysis of alternative methods for determining an optimum mixture of the indoor and outdoor systems will be used as a basis for developing a parametric structure for planning effective total systems."

OBJECTIVES

The overall objective of this study is to develop methods for determining the optimum mix of local warning facilities, where total system effectiveness is defined in terms of population coverage and the speed of dissemination. Systems considered in this study are taken as typical of other systems not included. For example, the telephone system was used as a study vehicle, while there are also radio-activated local warning systems (DIDS, NIAC, etc.) with an equal warning capability. It was not the objective of this report to select a specific system for local warning use but to develop a means of comparison of various systems. It is recognized that some redundancy is necessary, not only for complete coverage, but to provide authentication for maximum public response in the shortest period of time. This is the goal of any warning system in a thermonuclear missile attack environment.

ORGANIZATION

The report comprises four parts and an appendix. Part One, Research Procedures, describes the problem of developing a method for selecting an optimum mixture of warning systems, equipments or techniques and a research methodology for its solution. Two methodological tools are developed and described: standards of warning effectiveness and metropolitan population distributions. In Part Two these methodological innovations are used (with other data) to produce 24-hour warning effectiveness estimates for outdoor warning facilities, the Emergency Broadcasting System (during a crisis), the Crisis Home Alert Technique (for television) and telephone warning systems. These estimates define the coverage capability of the system at 5-, 15-, and 30-minute intervals.

The method for optimizing the warning system mixture is developed in Part Three. This method makes use of the standards of warning effectiveness and the individual estimates of system effectiveness as input data. It compares systems' effectiveness in several quantitative dimensions and assesses the resulting "optimum" mixture from a qualitative standpoint. Conclusions regarding the optimum mixture and the allocation of resources for system development are drawn from this analysis.

Part Four relates the warning effectiveness estimates to the goal of estimating increased survivors attributable to the optimum mixture. Procedures for making the system effectiveness estimates compatible with existing programs are described. The Appendix contains supplementary tables prepared for and used in the course of the project.

PART ONE: RESEARCH PROCEDURES

THE RESEARCH PROBLEM

A large number of existing and proposed techniques, equipments, and systems for alerting or warning the population have accumulated over the years without achieving the unitary aspect of a complete warning system. These discrete elements were largely devised in response to perceived needs and changing conditions. Each in its turn has been evaluated according to criteria that varied with the funding available, the nature of the existing threat, or the state of existing defenses. These elements were then deployed with various degrees of enthusiasm, or were shelved as a consequence of the evaluation effort or other considerations. If a common factor went into evaluating these warning elements, it was an assumption that, in a fully operational configuration, the system should provide warning in every threat situation; existing facilities were usually expected to become supplementary to the new "backbone" system or to serve specialized warning functions.

Recent research studies have clarified the need to match the system design to its mission or missions and to the environment in which it is to operate. Such an approach precludes the use of any single "all things to all men" technique or component--primarily because none has been found that can accomplish all the required tasks. It becomes necessary then, to seek individual components best suited to meeting expressed system requirements for the particular time or environment in which the components must operate. Such a warning system would comprise a mixture of elements interacting to optimize operations of the total system by providing the highest possible level of performance at the point and time of expected use.

Although several studies of warning system requirements have been conducted in the past, no concerted effort has been expended to develop usable methods for selecting an optimum mix of warning elements suited to the needs of a total

warning system. Such methods are essential if an integrated alerting and warning system is ever to be achieved. Planners would be able to use the methods to determine which components have maximum usefulness, thereby eliminating wasted effort. The costs saved by such an approach and the overall effectiveness achieved could be considerable: Existing systems could be reevaluated by these new criteria and perhaps modified to increase their value, incorporating new elements in quantity only where existing elements fail to fulfill the warning requirements.

The following sections of Part One describe the rationales and procedures used to solve this problem. When possible, the detailed tabular data were relegated to the Appendix so that the reader would not be inundated by figures; however where it is essential to the immediate discussion, referent data are presented in context.

RESEARCH METHODOLOGY

In the early phases of work on this project it became apparent that a satisfactory resolution of the major research problem would not be possible until two subordinate problems were solved. First, some procedure would have to be found for distinguishing between effective and ineffective warning performance. Although many factors contribute to warning system performance (including message credibility), two are basic to the process, quantifiable, and were specified in the scope of work as defining total system effectiveness. The factors to be used were population coverage and speed of dissemination. However, no information was available on what constituted the lowest acceptable rate of dissemination or the minimum standard for population coverage. Practically speaking, the problem was that reliable data measuring the actual (or most reasonable approximation) performance of the warning systems would be essential for making any evaluations of the system's actual or expected effectiveness. This need, of course, would have to be met separately for each system being evaluated.

The second problem, closely related to the first, was tnat of determining the approximate locations of large blocs of the population throughout the day and night. Without a relatively accurate estimate of the population distribution, warning system evaluations tend to be limited to the time period for which there are data--usually late at night. Clearly, any system designed for late night use would be substantially less useful when the population is scattered at locations other than their homes. It is less obvious--but equally true--that expanding the size of such a system so that adequate coverage is obtained by the sheer number of warning units would be costly. An accurate estimation of the population distribution was essential for developing round-the-clock warning effectiveness measures, which in turn, would be useful for raking determinations of a mixture of warning systems optimized on the basis of over-all, 24-hour coverage, rather than any single time period. Such an optimization procedure would almost certainly prove less costly to implement than one depending on an increase in the number of warning elements to increase 24-hour coverage.

REQUIREMENT FOR WARNING STANDARDS

A persistent difficulty in evaluating warning systems has been that of identifying performance standards uncontaminated by the systems being evaluated. Without independent performance standards it is common to find evaluators making invidious comparisons between systems, trying to find the best of the available alternatives.

Warning systems literature is replete with examples of this kind. The actual procedure is to select the system with the least (or most) of a given attribute, and rank order all other systems accordingly. This exercise is repeated with a number of variables for the set of systems being evaluated and a final determination of the best or optimum arrangement is made. The determination may be made on a cost/benefits basis, on an availability/benefits basis, or even intuitively as a function of the evaluator's judgment and experience. Although there are many uses of this approach, it tends to force choices between alternatives and can obscure the primary goal of obtaining uniformly

high overall warning performance. What happens is that the evaluator becomes embroiled in a controversy between systems rather than in an effort to use each system according to its unique strengths for the good of the whole warning process. As an additional hazard, the very flexibility of the evaluation procedure makes it tempting to set dollar limits on a system and search for the best warning buy. The risk of shopping for a warning bargain lies in ending up with an operational system rigidly limited to functions decided on a cost/benefits basis, with no assurance (except in the most costly systems) of complete and reliable warning performance.

Avoiding wasteful competition between systems can be facilitated when warning requirements are established prior to the actual analysis and evaluation. There have been two problems associated with this method. First, some system requirements are unmeasurable, either because there are no real-world equivalents to the ideal concepts or because data are unavailable. Second, when it is possible to measure the systems according to the requirements, the evaluation usually reveals that no single system is clearly superior on all counts. Thus, intrasystem competition begins as the evaluator makes trade-offs to optimize system effectiveness.

A major hinderance to overcoming the difficulty of obtaining uncontaminated performance standards is the implicit assumption that warning is a unique phenomenon and that the warning process must be investigated separately from other social behavior. Most likely the intent of viewing the warning process as though it occurs in a vacuum is to simplify the assessment of the various alternatives. True or not, this restrictive view imposes a seriously distorted understanding of the process--one that could produce gross inefficiencies in the allocation of limited funds and resources.

The warning process is beset with unique problems, but it should only be viewed as separate from normal communication channels for very limited purposes. A more exact analysis would have warning as a process logically external to

the normal process of disseminating important news to the public, that is, there are unique facilities and channels existing solely for the purpose of transmission and dissemination of warnings. These warnings facilities would provide some coverage at some rate of speed even if there were no "normal" process.

But of course there is such a normal process that could function to disseminate a warning or other important news item to some part of the population at some rate, even if there were no special warning system. The actual behavior of both processes is always the same: while warning is initially superimposed on the normal process, it is almost instantly incorporated as a major part of the normal process until no uninformed members of the public remain.[1]

A partial solution to this difficulty has been developed in the course of the present study. The approach used is to apply the findings of news dissemination studies to the warning dissemination process. In combination with mass media audience figures, these findings are extrapolated over a 24-hour period. This forms what is believed to be an approximation of the spread of news of any important, highly salient event to the public--provided no official intervention occurs.

This information represents the lowest, most fundamental level of warning effectiveness: the warning the public would receive if there were no official warning system, technique or facility. It is a standard of performance

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[1]Human error or misdirected zeal has sometimes acted to confuse the incorporation of warning into the normal process. A case in point occurred when a sound truck, commandeered for the purpose of warning the public of an impending flood, simultaneously continued its original mission of broadcasting the evening's bill and request for attendance at the community theater that same night. (Reported in Roy A. Clifford, The Rio Grande Flood: A Comparative Study of Border Communities in Disaster, No. 458, National Academy of Sciences, National Research Council, 1956.)

completely free of contamination from any warning system that might be measured or compared to it and one that clearly does not regard warning as a process occurring independently of its environment. However, as a solution to the problems described for other studies, it can only be regarded as incomplete and tentative. Certain information was simply not available--as is often the case--and while these omissions are noted, the gaps may appear large to some critics. More disquieting to the author, however, is the grossness of the data used in the study. Although this should not affect the overall validity of the findings, the quality of the quantitative materials makes confidence in the exact values rather difficult. To minimize the consequences of such inaccuracies, computations yielding finer data were rounded to the nearest million. This sometimes introduced additional problems in summations where data compose parts of a total. Considering the other difficulties experienced, inconsistencies of this order were simply ignored or made the subject of a footnote. It is hoped that further investigation along lines described in this report will contribute to a better and more complete understanding of the warning process.

NEWS DIFFUSION

The rate at which news spreads through a community or society and the sources of that news have long been of interest to students of the communication process. The earliest focus of attention was on the spread of rumors--a concern directly related to the conduct of World War II. It was during this period that the most research activity occurred.[1] Following the end of the war, rumor spread came to be seen as simply another form of news dissemination.[2]

From the concern with rumor spread, interest shifted to the more general question of "how does the news get around." The event precipitating a series of research

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[1]A rather complete discussion of rumor spread, couched in the language of the era, can be found in W. F. Vaughan, Social Psychology, Odyssey, New York, 1948, pp. 288-317.

[2]See especially, Tamotsu Shibutani, Improvised News, Bobbs-Merrill, New York, 1966.

studies into this question was the death of President Roosevelt.[1] Subsequent investigations dealt with similar events (i.e., those of national significance) from the 1953 death of Senator Robert Taft[2] to the 1963 assassination of President Kennedy[3] and beyond.

It is because this area has received so much attention over a period of time that social scientists were able to review the aggregated findings in search of general patterns. Although it is essential for our purpose that certain of the primary sources be used for exact data, the conclusions reached by these researchers are equally germane to our problem. Hill and Bonjean examined and compared (when possible) the research findings for six other news events in addition to their own data on the Kennedy assassination.[4] Although they offer their findings as hypotheses requiring further testing, the then available data were strongly supportive of the general conclusions, which are.[5]

"1. The greater the news value of an event, the more important will be interpersonal communication in the diffusion process.

2. The greater the news value of an event, the more rapid will be the diffusion process.

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[1] Delbert C. Miller, reported in R. J. Hill and C. M. Bonjean, "News Diffusion: A Test of the Regularity Hypothesis," Journalism Quarterly, Vol. 41 (3), 1964, pp. 336-342.

[2] O. N. Larsen and R. J. Hill, "Mass Media and Interpersonal Communication in the Diffusion of a News Event," American Sociological Review, Vol. 19, 1954, p. 429.

[3] Much of which has been collected into one book, Greenberg and Parker, The Kennedy Assassination and the American Public, Stanford University Press, 1965.

[4] Richard J. Hill and Charles M. Bonjean, "News Diffusion: A Test of the Regularity Hypothesis," Journalism Quarterly, Vol. 41 (3), 1964, pp. 336-342. The other news events were Roosevelt's death, launching of Explorer 1, Eisenhower's stroke, Alaskan statehood, Eisenhower's decision to seek a second term, and Taft's death.

[5] Ibid, p. 342.

"3. The importance of the various media as sources of information is in part a function of the daily routines of individuals. When these routines are interrupted by the occurrence of a major news event, the importance of the various media may be altered significantly.

"4. While certain socio-economic class differences may exist with respect to media use, these differences tend to be diminished in the case of the diffusion of an event of major impact."

Further testing of these hypotheses quickly followed. Researchers at the University of Iowa[1] took advantage of a period when public attention was focused on the mass media--the 1964 World Series--to collect data they used for this purpose. Two events of considerably different importance were chosen for the test: the arrest of Presidential assistant Walter Jenkins on a morals charge on October 14, and the involuntary resignation of Russian Premier Nikita Khrushchev on October 15. Their findings were highly supportive of the first two hypotheses quoted above.

The Khrushchev event was disseminated by personal contact in nearly one of five cases where the person was aware of the event. The Jenkins affair, however, was passed on by personal contact in only 3 percent of the informed cases sampled. The rate of dissemination was equally slanted in favor of the more important Khrushchev firing: within 30 minutes of the first reports, over 20 percent of the respondents learned of the Khrushchev firing, whereas it was 2-1/2 hours before 19 percent learned of the Jenkins event; after 3 hours, 70 percent were aware of Khrushchev, but it was over 10 hours before even 60 percent were aware of Jenkins. Furthermore, the differences were consistent at all subsequent times.

[1]Richard W. Budd, Malcolm S. MacLean, Jr. and Arthur M. Barnes, "Regularities in the Diffusion of Two Major News Events," Journalism Quarterly, Vol. 43, 1966, pp. 221-230.

The third hypothesis--the importance of various media as sources of information being related to the daily routines--was only partly supported by the research findings. Over half those hearing of one event on radio, heard of the other by the same medium. Nearly 65 percent of those learning of one event by television learned of the other by that medium. Of those learning of one event by newspapers or by personal contacts, about 30 percent learned of the other from the same source. The authors feel that these data are suggestive of routinized use of the media, but are not so clearly supportive of this hypothesis as for the two preceding hypotheses. Neither event was of sufficient importance to interrupt these routines and a test of the concluding part of the third hypothesis was not attempted.

The fourth hypothesis, concerning the lessening of media use differences stemming from socioeconomic class differences in the dissemination of news of major impact, was not supported. However, it seems difficult to believe that either of the events had a major impact on American society.

These "interpretive" studies of research in aggregate offer what are probably the best justifications for the assumptions made in the present study of the relationships between warning and very important news, insofar as disseminating either without official intervention is concerned. The first hypothesis (strongly supported by both studies) provides clear support for this case. "The greater the news value of an event, the more important will be interpersonal communication in the diffusion process." Warnings, of course, have an appreciable value as news and as life-saving information. Without belaboring the point, it seems quite reasonable to expect personal communication to play a major part in the dissemination of warning. As for the second hypothesis that the more important an event, the faster will be the diffusion process, warning is again in position to benefit from this phenomenon.

The third hypothesis that when daily routines are interrupted by the occurrence of a major news event, the importance of the various media may be altered significantly, appears most relevant to warning during a crisis buildup. At such a

time, patterns of media usage will shift--mostly upward. Except in cases such as the Power Blackout occurring on the East Coast in 1965 (when battery-operated radios were the only news source), the move will be to television. At such times, the dissemination of warning will be greatly facilitated by the increase in audience.

The last of Hill and Bonjean's hypothesis that "while certain socio-economic class differences may exist with respect to media use, these differences tend to be diminished in the case of the diffusion of an event of major impact," is less clearly related to the warning issue. At most it indicates that the increase in media use during major events will be evenly distributed among the population. To the extent that any group might have been "unwarned" this phenomenon is important, but the prospect of systematic exclusion seems unlikely. In fact, the mutual aid and group participation occurring in emergency situations is so well known as to make any other possibility seem rather improbable. .

From a practical standpoint, the issue may not be one of providing additional support for the rather obvious relationship between warning and the diffusion of other high saliency news, but of describing that diffusion process in a way relevant to the warning situation. For this purpose the research findings in news dissemination following high saliency events were collected. These are shown in Table 1-1. As is usually the case, there is considerable variability in the completeness of data reported in each study. Of the studies reporting time and population coverage data, only one reported the proportion informed within 5 minutes of the event. The majority made their first measurement at 1/2 hour and two obtained their first data 1 hour after the event. By and large, there is general agreement on the rate of news diffusion in the most important events covered: roughly 25 percent of the population learned in the first 5 minutes after the news was "out," another 10 percent or so in the next 10 minutes, about 25 percent more by 1/2 hour and, at the end of an hour, about 90 percent of the total population was aware of the event. Taken literally, these data provide only the roughest estimate of high saliency news dissemination.

Table 1-1. Summary of Survey Data Used in Determining High Saliency News Dissemination Coverage Rates

EVENT	SAMPLE SIZE	SAMPLE AREA	TIME BETWEEN EVENT AND INTERVIEWS	PERCENT AWARE WITHIN: 5 MINUTES	15 MINUTES	30 MINUTES
1. Kennedy Assassination	151	Iowa City	1 day	-	-	70
2. Kennedy Assassination	419	San Jose	10 days	26	40	63
3. Oswald Shooting	123	Iowa City	1 day	-	-	57
4. Kennedy Assassination	212	Dallas	7 days	-	66	83
5. Kennedy Assassination	1384	National	8 days	-	-	-
6. Khrushchev Firing	320	Iowa City	2 days	-	-	21
7. Roosevelt's Death	Unk	Unk	Unk	-	-	-

Sources:

1. S. P. Spitzer and N. S. Spitzer, "Diffusion of News of the Kennedy and Oswald Deaths," in B. S. Greenberg and E. B. Parker, eds., The Kennedy Assassination and the American Public, Stanford Univ. Press, 1965, pp. 99-111.
2. B. S. Greenberg, "Diffusion of News About the Kennedy Assassination," ibid., pp. 89-98.
3. Spitzer and Spitzer, ibid., pp. 99-111.
4. C. M. Bonjean, R. J. Hill and H. W. Martin, "Reactions to the Assassination in Dallas," ibid., pp. 178-198.
5. P. B. Sheatsley and J. F. Fieldman, "A National Survey of Public Reactions and Behavior," ibid., pp. 149-177.
6. R. W. Budd, M. S MacLean, Jr., and A. M. Barnes, "Regularities in the Diffusion of Two Major News Events," Journalism Quarterly, Vol. 43, 1966, pp. 221-230.
7. D. Miller reported in O. N. Larsen and R. J. Hill, "Mass Media and Interpersonal Communication in the Diffusion of a News Event," American Sociological Review, Vol. 19, 1954, p. 429.

In a situation where speed of operation is paramount (as is not exactly the case in any of the events for which data are available), the dissemination of news might be faster. This could affect radio and television transmission as they are linked by Teletype and equipped with EBS pre-tuned receivers which could be used to speed up the process. Those learning from other sources would not be directly affected.

News Sources

As suggested in the preceding discussion, measuring the rate at which news travels through a population provides only a superficial understanding of the phenomenon. To complete this understanding and to provide data for subsequent analysis, it is necessary to isolate the contribution of each major initial source of silent news and its particular rate of transmission. In accomplishing this task, nine studies providing news source were investigated and the results shown in Table 1-2. These data, too, are somewhat spotty in completness and quality; in general, there is a rough consensus on the actual proportion informed by each medium.

About half the public learns from radio or television and half from personal contacts. In all the studies reviewed only one provides any refinement of the personal contact data, showing that 40 percent of the people were contacted on a face-to-face basis and 10 percent by telephone. For this reason and because the data seem representative of the findings of the other studies, results obtained by Greenberg[1] are used in this report. These results are:

1. Radio was the first source of news for 28 percent of the public.
2. Television was the first source of news for 22 percent of the public.
3. Telephone was the first source of news for 10 percent of the public.
4. Face-to-face was the first source of news for 40 percent of the public.

[1] Greenberg, op. cit., Table 2, p. 94.

Table 1-2. Summary Survey Data Used in Determining High Saliency News Sources

EVENT	SAMPLE SIZE	SAMPLE AREA	TIME BETWEEN EVENT AND INTERVIEWS	PERCENT LEARNING BY:		
				RADIO	TELEVISION	PERSONAL CONTACT*
1. Taft's Death	129	Seattle	1 day	54	5	35
2. Taft's Death	125	Seattle	1 day	43	25	17
3. Khrushchev's Firing	320	Iowa City	2 days	34	35	19
4. Kennedy Assassination	151	Iowa City	1 day	25	19	55
5. Kennedy Assassination	114	Denver	9 hours	13	9	76
6. Kennedy Assassination	419	San Jose	10 days	28	21	50
7. Kennedy Assassination	100	Dekalb, Ill.	Unk	22	13	65
8. Kennedy Assassination	212	Dallas	7 days	17	26	57
9. Oswald Shooting	123	Iowa City	1 day	21	50	29

*Includes telephone calls.

Sources:

1. O. Larsen and R. J. Hill, op. cit. The "University" sample.
2. Ibid., The "Working Class" sample.
3. R. W. Budd, M. S. MacLean, Jr., and A. M. Barnes, op. cit., p. 223.
4. S. P. Spitzer and N. S. Spitzer, op. cit., p. 104.
5. T. J. Banta, "The Kennedy Assassination: Early Thoughts and Emotions," Public Opinion Quarterly, Vol. 28(2), 1964, p. 218.
6. B. S. Greenberg, op. cit., p. 93.
7. W. Burchard, reported by S.P. Spitzer, "Mass Media vs. Personal Sources of Information About the Presidential Assassination," Journal of Broadcasting, Vol. 9(1), 1965, p. 47.
8. R. J. Hill, C. M. Bonjean, and H. W. Martin, op. cit., p. 339.
9. S. P. Spitzer and N. S. Spitzer, op. cit., p. 104.

News Source Effectiveness Rates

It is important to note that these figures represent proportions of the total first source of news. They do not reflect the rate at which the news is transmitted by each medium over time--data, incidentally, which is particularly relevant to the warning task. As shown in Table 1-3, there are important differences in the rate at which each source disseminates news to the public.

Table 1-3. News Source Effectiveness within Half an Hour as a Percentage of Total Audience per Medium Reached at Each Interval.

MEDIUM	0-5 MINUTES	6-15 MINUTES	16-30 MINUTES	CUMULATIVE 0-30 MINUTES
Radio	35%	12%	35%	82%
Television	48	28	21	97
Telephone	4	1	4	9
Face-to-Face	12	4	18	34

Source:

Based on Greenberg, op. cit., pp. 92-94.

Radio, for example, is shown to reach 35 percent of the radio audience within the first 5 minutes, an additional 12 percent in the following 10 minutes and another 35 percent in the next 15 minutes for a total of 82 percent of the radio audience. At the time the news of the Kennedy assassination was first disseminated (between 1:30 and 2:00 PM, EST), there were approximately 36 million listeners in the radio audience. Of course, not all were listening attentively and all radio stations did not begin broadcasting the news at the same time. This probably accounts for the fact that it was a half hour before 30 million of the total audience were aware of the event.[1] As all the radio

[1]Audience data are based on the 1967 Broadcasting Yearbook, Broadcasting Publications, Inc., Washington, D.C., 1967, pp. 19-20.

stations announced the shooting and as new listeners (previously uninformed) began to tune in to radio receivers, the remaining 18 percent were added to the total informed by radio.

A slightly different interpretation is required for personal contact sources of news. Telephone and face-to-face contacts were assumed to have not been listening to the radio or watching television in these calculations. Thus, all people not in the mass media audience were potential recipients of an interpersonal first source of the news. This means that the rate for first learning the news from personal contacts has to be based on the 120 million people not watching television or listening to radio and, while the actual numbers involved are many (41 million in the first half hour), the large base causes the resulting percentages to be relatively small (only 34 percent in the first half hour).

In sum, the table data suggest that television is by far the fastest source of high saliency news within the first half hour. Radio is a strong second, followed by face-to-face contacts and telephone, in that order. Of course, when these data are compared with the overall percentages of the total reached, it is evident that no single source is altogether superior to the others. Television and radio were fastest, but the larger audience potential of the personal contact sources made the process extremely thorough and ensured complete coverage of the population.

News source effectiveness rates serve as the basis for the following standards of warning effectiveness estimates. Based as they are on empirically determined news dissemination data and on audience measurements accepted by the broadcasting industry, these basic effectiveness rates appear relatively realistic. If anything, as standards they will tend to reflect a consistently conservative estimate of performance, inasmuch as the broadcasters and public are probably more experienced now in disseminating significant news than during

the events on which these data were collected. In the ensuing years, other high salience events have occurred and have been disseminated by the media and personal contacts and, while the interest in measuring news flow has slowed, it is likely that news events are disseminated even faster today.

STANDARDS OF WARNING EFFECTIVENESS

The effectiveness rates for each news source for important events provides an instructive but incomplete view of the dissemination process as it relates to the problems addressed by this paper. To be of use to warning system evaluation, it is necessary to apply these empirically based rates to the circumstances existing at any time a warning system might operate. This requires combining hourly audience measures (and nonaudience complements) with basic effectiveness rates. The result is a series of 23 hourly estimates of news source effectiveness. The procedure assumes that the rate at which each source disseminates news to the populace is fixed. However, the size of the population available to each source is variable according to the measured mass media usage habits of the public. Thus, while television is able to reach 92 percent of its audience in a half hour, the number of people actually reached will be low during times of low TV use and extremely high in "prime time." Because those not using radio or television are assumed to be potential recipients of a telephone call or face-to-face word of the event, the numbers so informed will vary inversely with the size of the radio or television audiences.

The logic of these assumptions may be debatable--several flaws are readily apparent. For example, the rate at which radio and television disseminate news will almost certainly be faster during each medium's peak use period: in the morning commuting hour for radio, in the evening prime entertainment hours for television. Not that increased numbers would affect these rates, but rather that people are more likely to be attentive to the medium at these times and not so likely to use it for background noise or be otherwise

occupied. The use of these rates during the late night hours probably overstates the speed of transmission by at least the time required to arouse sleepers. On the other hand, the telephone would certainly be used more in disseminating important news late at night than in the day when the mass media are obviously providing adequate coverage (this assumes that one is more inclined to use the phone to alert someone not likely to be informed by another source and not waste the effort on someone else likely to be informed already). However, since correction factors for these deviations are not available, the assumption is that they will tend to either cancel one another or that the net effect is to produce conservative rather than overly optimistic estimates.

The data presented in Table 1-4 and in Tables A-1 through A-6 in the Appendix were derived from the basic effectiveness rates and audience data. Because they combine data obtained from different sources and intended for different purposes, some explanation is required.

Of particular importance are the sources and handling of the audience data. The radio figures were compiled for the Radio Advertising Bureau in 1964 by Sindlinger and Company.[1] In their raw form they are arrayed from 6 AM to 12 PM as the percentage of all adults (18 or older) listening to radio during a time segment. Although there was some risk of losing accuracy in the transposition, it seemed that using the percentage as reflecting percentages of the total population would be better than adding estimates of children's use patterns or correcting the data according to the proportion of children in the population. Generally speaking, children are either under the supervision of adults or have access to transistor receivers, car radios, etc., and will probably be as informed of major events as adults. It was also assumed that the radio listening habits did not change perceptably between 1964 and 1966. Therefore, for the sake of consistency, these percentages were applied to 1966 population census estimates.

[1] 1967 Broadcasting Yearbook, op. cit., p. 20.

Table 1-4. Dissemination of High Saliency News to Population (in Millions Reached) by Source, per Time Segment

TIME	RADIO				TELEVISION				TELEPHONE				FACE-TO-FACE			
	MEDIUM AUDI-ENCE	MINUTES			MEDIUM AUDI-ENCE	MINUTES			POTEN-TIAL RECIPI-IENTS	MINUTES			POTEN-TIAL RECIPI-IENTS	MINUTES		
		0-5	6-15	16-30		0-5	6-15	16-30		0-5	6-15	16-30		0-5	6-15	16-30
1 AM	3*	1	-	1	13*	6	4	3	178	7	2	7	178	21	7	32
2	2*	1	-	1	7*	3	2	1	186	7	2	7	186	22	7	33
3	X	X	X	X	X	X	X	X	194	8	2	8	194	23	8	35
4	X	X	X	X	X	X	X	X	194	8	2	8	194	23	8	35
5	X	X	X	X	X	X	X	X	194	8	2	8	194	23	8	35
6	25	9	3	9	1	-	-	-	168	7	2	7	168	20	7	30
7	47	16	6	16	7	3	2	1	140	6	1	6	140	17	6	25
8	47	16	6	16	16	8	4	3	131	5	1	5	131	16	5	24
9	46	16	6	16	24	12	7	6	124	5	1	5	124	15	5	22
10	42	15	5	15	29	14	8	6	123	5	1	5	123	15	5	22
11	39	14	5	14	33	16	1	8	122	5	1	5	122	15	5	22
12	36	13	4	[illegible]	38	18	11	8	120	5	1	5	120	14	5	22
1 PM	33	12	4	12	41	20	11	9	120	5	1	5	120	14	5	22
2	31	11	4	11	42	20	12	9	121	5	1	5	121	15	5	22
3	31	11	4	11	45	22	13	9	119	5	1	5	119	14	5	21
4	33	12	4	12	48	23	13	10	113	5	1	5	113	14	5	20
5	35	12	4	12	52	25	15	11	107	4	1	4	107	13	4	19
6	33	12	4	12	66	32	18	14	96	4	1	4	96	12	4	17
7	30	11	4	11	81	39	23	17	82	3	1	3	82	10	3	15
8	27	9	3	9	95	46	27	20	72	3	1	3	72	9	3	15
9	23	8	3	8	102	49	29	21	69	3	1	3	69	8	3	12
10	21	7	3	7	96	46	27	20	77	3	1	3	77	9	3	14
11	17	6	2	6	73	35	20	15	104	4	1	4	104	12	4	19
12	8*	3	1	3	34*	16	10	7	153	6	2	6	153	18	6	28

Key:

* Data Not Complete
X Data Not Available
\- Less than 1 Million
☐ "Boxed" data for 1 PM are based on data in Table 1-3, observed rates of news source effectiveness. All other table data are extrapolated from these effectiveness rates as explained in text.

Audience measures for television were obtained from the A.C. Nielsen Company, Nielsen Television Index (NTI) for March-April 1966.[1] These figures were reported by the number of homes watching television during each hour from 6 AM to midnight. There was less chance for error with these data First, it is a relatively easy matter to determine the number of people composing each audience by multiplying the number of households by the average number of people per household.[2] Second, it was possible to compare the 1966 NTI data with 1968 NTI figures for the same hours.[3] There were usually more households watching television in 1968. However, the increases appeared regular and were interpreted to reflect the increase in population rather than changes in television viewing patterns.

Both sets of audience data (once they were converted into numbers of people) were normalized for time zone differences. This procedure necessitated assuming that the proportions of people listening to radio or watching TV in each time zone were equal, or at least that there were no major behavioral differences resulting from geographical location. A fairly accurate count was then made of those living in each of the four U.S. time zones by tallying their numbers on a state-by-state (or portion thereof) basis from the 1966 census estimates and a time zone map. This tally yielded the following percentages in each zone:

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[1] 1967 Broadcasting Yearbook, op. cit., p. 20.

[2] Based on total U.S. population for 1966 divided by total households for 1966, yielding 3.1 per household. This value should not be confused with family size (3.31), as it includes primary individuals as well as primary families.

[3] 1969 Broadcasting Yearbook, Broadcasting Publications, Inc., Washington, D.C., 1969, p. 26.

Eastern Standard Time (EST)	51.5
Central Standard Time (CST)	31.9
Mountain Standard Time (MST)	4.2
Pacific Standard Time (PST)	12.4
	100.0

By determining the numbers listening in each time zone at each hour, the totals for any given time could be determined by adding (to EST) the audiences for the corresponding hour in each of the other zones. In this way, the audience figures reflect the numbers actually in the audience at any moment and not, as is usual in the broadcasting industry, the audience during a particular "time-slot." This adjustment is essential for the warning situation, since the threat would materialize at a particular moment without reference to U.S. time zones.

The effect of making the adjustment for time zone differences is to close some of the late night gaps in audience measurements with partial data. These incomplete data periods began with the midnight to 1 AM period, since that was the cutoff time for the EST audience. By the 2 to 3 AM period, the figures reflect only the PST audience. After 3 AM there are no data available until 6 AM EST. At this time the early morning EST audience begins to take form. Then, at 7 AM, the CST audience joins, followed at 8 AM by the MST audience. The audience is completed during the 9 to 10 AM period, when the PST data are included. The consequence of underestimating the audience size during these hours is to produce a generally conservative late night picture of the dissemination of high-saliency news. However, these estimates are probably accurate approximations and do constitute an improvement over no data at all. As previously noted, the population-reached estimates are obtained by computing the proportion of the medium audience from the news source effectiveness rates of the medium. Thus television, which actually served as the first source of news to 48 percent of its measured audience within 5 minutes, is calculated to reach 48 percent of its audience in 5 minutes at any time news of a major event is disseminated.

As the television audience varies from a low of about 1 million at 6 AM EST to a high of 102 million during the 9 PM segment, the numbers reached in 5 minutes by that medium alone can be readily estimated. In the former case the number reached would be about half a million--too low to be reported in Table 1-4; in the later period, approximately 49 million would receive their first news of a major news event from television within 5 minutes. The estimates for the next 10 minutes and from 16 to 30 minutes are derived from the same effectiveness rates shown for each medium and time in Table 1-3.

The personal contact sources have a wider range in numbers of "audience" or, more correctly, potential recipients than have the other sources. As the decisions were made to include all those not in the radio or TV audience as capable of being first informed by personal contact, the number involved must be the difference between the combined audiences of the media and the total population. As there is a period of 3 hours when no audience was available, it was necessary to assume that all the U.S. population were potential recipients of personal contacts for high saliency news. Unrealistic as this may seem, no better data were available and, when the numbers likely to be in the mass media audience during this period are considered, the loss is minor.

WARNING STANDARDS, VALIDITY AND RELIABILITY

Now the following question arises: Are these hour-by-hour estimates of news source effectiveness useful performance standards against which warning system performance can be compared, evaluated and optimized?

There are two tests (short of a nationwide practical exercise) for any such predictive instrument: the validity of the tool and its reliability. Both have previously been discussed in this section, although from the perspectives of exposition and justification. Regarding the validity of these performance standards, it was noted that there are several shortcomings in completeness of data and in the viability of the assumptions. Although determining the effect

of these limitations is probably an individual decision, weight should be given to such strong points as the empirical sources of the data, the general agreement between findings of different researchers regarding dissemination of news, the tendency for such limitations as were noted to ensure conservative rather than overly optimistic estimates, and the fact that no effort is made to regard the data as more than approximations of the population coverage and of the speed of dissemination of important news for normal communication channels.

The reliability of these estimates can only be inferred from the nature of the source materials. In addition to the research cited previously in this section, other communication studies[1] were examined in the course of project work. In no case were findings uncovered contrary to the interpretations made in this study. When the events being studied and the methodology employed were comparable, the findings were consistent.

Also supporting the assertion of reliable estimates is the fact that the audience measures were obtained from a source used by both broadcasting and advertising industries to aid in making significant business decisions. Broadcasters determine their charges for advertising on the basis of the audience reached; advertisers determine the amount they will spend partly as a result of the cost per audience member reached. With the sums involved (over $3 billion for radio and TV combined)[2] it is clearly in the best interest of both industries to obtain the best possible measures of the audience.

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[1] A partial listing of the most germane includes: E. D. Rose, "How The U.S. Heard About Pearl Harbor," Journal of Broadcasting, Vol. 5, 1961, pp. 284-298; A. M. Barban and C. H. Sandage, "Illinois Farmers' Use of Media during Arab-Israeli Conflict," Journalism Quarterly, Vol. 45, 1968, pp. 336-337; J. T. McNelly, R. R. Rush and M. E. Bishop, "Cosmopolitan Media Usage in the Diffusion of International Affairs News," Journalism Quarterly, Vol. 45, 1968, pp. 329-332; R. Lachman, M. Totsuoka and W. J. Bonk, "Human Behavior During the Tsunami of May 1960," Science, Vol. 133, No. 3462, 1961, pp. 1405-1409; M. S. MacLean, Jr., "Mass Media Audiences: City, Small City, Village and Farm," Journalism Quarterly, Vol. 29, 1952, pp. 271-282; M. Samuelson, et al., "Education, Available Time and Use of Mass Media," Journalism Quarterly, Vol. 40, 1963, pp. 491-498; and T. Shibutani, Improvised News, op. cit., pp. 31-62.

[2] 1969 Broadcasting Yearbook, op. cit., p. C-55.

However, even if these standards of warning effectiveness are only partly valid and reliable, they do constitute an improvement over the more static methods. Also, as tentative as they are, they are just the first step in the process of optimizing the allocation of warning systems, techniques, and facilities. If the remainder of the steps prove successful, these standards will have an opportunity to prove their usefulness to the goals of the project by the products of the task itself. The remaining steps are described in the following sections.

POPULATION DISTRIBUTION

The single most vexing problem for this and other studies of warning system effectiveness has been locating the population in space and time. Without a thorough understanding of these population dynamics, system evaluations are restricted to one of three alternatives: 1) evaluate the system at a time the population location is known (most often the census population); 2) limit the area(s) in which the system is to be evaluated so that the census period data can be supplemented by estimates of peak capacity (e.g., where the maximum capacities of schools, businesses, recreational areas, etc., are tallied and used to approximate noncensus-period population levels); and 3) limit the range of warning system installations to those locations where the population level is more or less fixed, e.g., military bases, schools, other public buildings, jails, offices, etc.

None of these means of dealing with the lack of data is entirely satisfactory. Using only the nighttime census figures is the least desirable, since the great daytime work/school surges in population movement are not accounted for in the analysis. Picking certain areas for a known peak capacity barely represents an improvement. The biggest problem is that the best that can be hoped for are very rough approximations of population dynamics in one or two additional time blocks: the work/school period, the commuting period(s) and finally, the standard census data period.

The most accurate, but least useful, is the evaluation of systems terminating at points of relatively fixed populations. Systems such as this (NAWAS or DIDS) are not properly warning systems as far as the public is concerned. As is explicit in the DIDS (Decision Information Distribution System) acronym, these systems distribute information. Even when the terminal is a radio or television broadcast station, the contribution of a distribution system can only be in terms of reducing the time required to warn, not in improving the warning coverage. For this reason it is clear that although the most accurate count of people near such termini provides an effectiveness measure for the system, it will not provide any more information on the public's location over time than did the limited area analysis approach. In fact, except that distribution systems are not expected to directly "warn" the resident census population, they are little more than incomplete, limited area analyses.

This report does not propose to solve the population dynamics problem at one stroke. That solution will require either an elaborate, special census or a highly complex model of the multiple behaviors contributing to the population flux. Instead, what is offered is a method for estimating population variations in at least a major segment of the U.S.--the metropolitan areas. The improvement over the three previously described approaches provided by this method is more quantitative than qualitative, that is, more people are "counted" more of the time but there are still missing data and less than certain assumptions being used.

DISTRIBUTION OF CITY POPULATION IN TIME

The procedure used in deriving these estimates is typical of the general project approach outlined thus far: juxtaposing the findings for one research area with those of another. In this case it was necessary to use figures showing the ratio of people in each of three types of city areas, normalized for 3 AM, and other data describing residential density and land use for different cities. These cities had some elements in common: they were American and provided

measures obtained after WW II (between 1947 and 1965). With the exception of Philadelphia-Camden, N. J., the populations of the cities ranged between 100,000 and 1,000,000. The Philadelphia-Camden complex had a population of about 2-1/2 million in 1950, three years before the data were gathered.

The assumption made in this study is that when the data from the separate cities are grouped together and only their averages used, the variations found between cities will tend to be evened out or minimized. There is some reason to believe that this is the case.

Wurtele and Wellisch[1] tested this assumption and found statistical evidence in its favor. Their data were originally obtained by the University of North Carolina (1952) for the cities of Erie, Flint, Grand Rapids, Minneapolis-St. Paul, and Philadelphia-Camden. Wurtele and Wellisch obtained for each city and area type the ratios of those present at every other hour of the day to those present at 4 PM. Statistical analysis of these data showed that variations in population distribution between the different times were significantly greater than variations between cities. This evidence was regarded by the authors as sufficient to justify using data obtained from one region or city for other areas.

Using such data in the aggregated form, as averages of all the cities, would appear even more defensible than using data from only one city as representative of all. This of course was the method used for this study. The first step was to obtain averages for the data on which Wurtele and Wellisch performed their tests.[2] The averages were computed for the five cities' residential, commercial, and industrial areas for all 24 hours. Data covering persons in motion in

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[1] Zivia S. Wurtele and Jean B. Wellisch, Population Dynamics, System Development Corporation, TM-L-4146, December 1968, pp. 30-32 and 67-74.

[2] Ibid., pp. 67-69.

vehicles were not averaged for the cities, although they were available. The reasoning was that determining a numerical base from which the numbers at every other time could be computed would be less rewarding than the effort required. As Neilson and Lamoureux[1] point out, those in vehicles are probably best reached by radio (auto or portable). Thus, their "status" of being in transit is less relevant than that of being in the radio audience. Also, inasmuch as even those in transit are somewhere, they can just as easily be counted as being in commercial, industrial or residential areas--at least during the period of transition.

Since it was necessary to produce numerical estimates of the population distribution over time, the next step was to normalize these ratio-averages for a 3 AM time period rather than 4 PM, as used in the source document. These normalized ratios for each area type are shown in Table 1-5. The purpose in shifting the base hour to 3 AM was to set up the conversion into actual population values on the most substantial information available--residential census data. In this way, after the proportion of those living in each area was known, it would be possible to calculate the increase and decrease of those in each area from a known population base number.

DISTRIBUTION OF CITY POPULATION IN SPACE

The procedure at this point was to obtain a sampling of population distributions according to the area type. It was quickly determined that the average land use percentage pattern for the developed areas of cities was as follows:[2]

All Residential	55.0
All Industrial	15.8
Commercial	4.6
Parks and Playgrounds	9.4
Public and Semipublic Property	15.2

[1] J. O. Neilson and R. L. Lamoureux, Improved Outdoor Alerting and Warning, System Development Corporation, TM-L-3787/002/01, October 1968, pp. 87-88.

[2] Excludes roads from being considered as developed, although nearly 16 percent of the total area in cities is so used. The data are from Harland Bartholomew, Land Uses in American Cities, Harvard University Press, Cambridge, 1955, p. 121.

Table 1-5. Ratio of People in Area at Time Listed to Those in Area at 3 AM (Census) Normalized from Five City Averages

TIME	RESIDENTAL AREAS	COMMERCIAL AREAS	INDUSTRIAL AREAS
1 AM	.99	1.05	1.28
2	1.00	1.05	1.05
3*	1.00	1.00	1.00
4	1.01	1.00	.91
5	1.02	.96	.93
6	1.01	.98	1.01
7	.95	1.15	1.53
8	.86	1.97	2.13
9	83	3.60	2.45
10	.81	4.55	2.48
11	.78	5.19	2.48
12	.78	5.37	2.46
1 PM	.77	5.32	2.42
2	.75	5.58	2.47
3	.74	5.58	2.56
4	.75	5.26	2.30
5	.79	4.14	1.72
6	.88	1.87	1.35
7	.89	1.72	1.32
8	.85	2.29	1.29
9	.86	2.25	1.31
10	.90	1.85	1.30
11	.93	1.45	1.31
12	.96	1.15	1.22

Data based on the University of North Carolina (1952) study cited in Wurtele and Wallisch, op.cit., pp. 67-73, and covers Erie, Flint, Grand Rapids, Minneapolis-St. Paul, and Philadelphia-Camden.

*Census data.

However, it is clear that very little of a city area is really characterized by only one function. Industrial areas have clusters of homes pocketed within their borders. Residential neighborhoods have small service centers--a market, some shops, etc. It is basically the commercial areas of a town where apartment houses, hotels, and motels can be found. Since there is a resident population in these areas, by determining its size and proportion to the whole, changes in the total caused by transients can be calculated from the hourly changes in population ratios.

Passonneau and Wurman[1] conducted block-by-block surveys of twenty American cities, enumerating the important characteristics of each block. These data were then coded (using colors and symbols) and superimposed on large maps of each city. Unfortunately, the researchers provided no summary data for any of the cities or their characteristics. Therefore, extracting any such summaries would require manual tabulation, from the base maps to tally sheets, and then conversion into population counts and percentages.

To hold the opportunity for counting and other errors to a minimum and because the work was particularly tedious, the decision was made to extract the block-by-block determination of land use and resident population size. Since there were no residents in areas categorized as park lands or public property, it was necessary to make only commercial and industrial counts--residential counts being the remainder of the city population. The findings of this secondary analysis of the Passonneau and Wurman data are shown in Table 1-6.

The three cities (New Orleans, Atlanta and Denver) were selected on the basis of being medium-sized cities not particularly distinguished by functional uniqueness (as would be a city like West Covina, California, for its "bedroom city" function, or Bethlehem for its "steel town" industrial image). At that,

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[1] J. R. Passonneau and R. S. Wurman, Urban Atlas: 20 American Cities, MIT Press, Massachusetts, 1966.

Table 1-6. Proportions of City Population Living in Residential, Commercial and Industrial Areas--Three Cities.

CITY	1960 POPULATION	PERCENT RESIDENTIAL	PERCENT COMMERCIAL	PERCENT INDUSTRIAL
New Orleans	627,526	80.2	12.3	7.4
Atlanta	487,455	90.3	4.3	5.5
Denver	439,887	78.8	16.6	4.6
Three-City Averages	--	82.2	11.6	6.2

Source:

Passonneau and Wurman, op. cit., passim.

the three cities show a remarkable homogeneity of population distribution into each of the areas. In all cases the vast preponderance of the population lives in residential areas. Only Atlanta falls below 10 percent of the residents living in commercial areas (suggesting that there were comparatively few apartment houses in the downtown area of Atlanta), but all three cities have close to the same percentages of their populations living in their industrial areas. The averages for the three cities can probably be taken as representative of most American cities-- as the perturbations introduced by one kind of special-purpose city are probably offset (on the average) by the perturbations of another.

At this phase of the work only one barrier remained to successfully determine the metropolitan population distribution: population living in the fringe areas of the cities. The data describing the ratios of people in different areas were gathered for cities--although there was no reason to expect variations within similar areas located in the city fringe. The proportions of people living in each of the functional areas outside the central city, however, were likely to change as a consequence of the different location. Because there is more available space in the communities outside of central cities, there tends

to be less need for intermixing housing with commercial or industrial land uses. Recent zoning regulations help maintain this functional separatism by encouraging the development of shopping centers and industrial park areas. Even the commercial strips growing up along arterial roadways are frequently surrounded by parking lots and green belts for the explicit purpose of shielding the residential areas from noise and traffic.

Unfortunately it was not possible to locate any data useful for adjusting the central city population distributions to the urban fringe condition. The solution used was arbitrarily to cut the proportions living in commercial and industrial fringe areas in half: where 12 percent lived in the city's commercial areas, 6 percent were estimated for fringe areas; where 6 percent of the city population lived in the industrial sections, only 3 percent were estimated for similar areas outside the central city. As a consequence, the proportion of people living in residential areas went from 82 percent to 91 percent.

DISTRIBUTION OF POPULATION IN METROPOLITAN AREAS--24 HOURS

The final phase of this part of the project was to compute the metropolitan population distribution for the initial census period and the following hourly intervals. The results, presented in Table 1-7, reflect the combined total of central-city and outside-central-city populations for each area.

Deriving the data in Table 1-7 entailed two major steps. First was to determine the 3 AM resident population for each area type. This was accomplished by taking the proportion living in each area type (shown in Table 1-6 for central cities and estimated in the preceding paragraph for the urban fringe) from the 1966 metropolitan census data.[1] This step revealed that there were 48.7 million

[1] Statistical Abstract of the United States, 1968, Department of Commerce, GPO, Washington, D.C., 1968, Table 17, p. 18.

Table 1-7. Metropolitan Population Distribution (in Millions) Estimates for U.S.--1966 Central City and Urban Fringe Combined

TIME	NUMBER IN METROPOLITAN RESIDENTIAL AREAS	NUMBER IN METROPOLITAN COMMERCIAL AREAS	NUMBER IN METROPOLITAN INDUSTRIAL AREAS	** TOTAL
1 AM	107	12	7	126
2	108	12	6	126
3*	109	11	6	126
4	110	11	5	126
5	110	11	5	126
6	109	11	6	126
7	104	13	9	126
8	90	21	11	123
9	79	36	12	127
10	72	45	12	129
11	67	50	12	129
12	67	51	12	129
1 PM	66	51	12	129
2	64	53	12	129
3	63	53	12	128
4	66	51	11	128
5	75	42	9	126
6	94	24	7	122
7	96	19	7	122
8	90	25	7	122
9	91	25	7	122
10	96	20	7	123
11	98	16	7	123
12	104	13	7	123

Key:

*Approximate census--resident population of area.
**Row totals may reflect rounding errors.

central-city residential area residents, 7.1 million central-city commercial area residents, 3.6 million central-city industrial area residents, and 59.9 million urban-fringe residential area residents, 3.9 million urban-fringe commercial area residents, and 1.8 million urban-fringe industrial area residents. The total for central city and urban fringe combined is shown in Table 1-7 as the metropolitan population for each area at 3 AM.

The second step was to determine the hourly variations in population for the central city and urban fringe. This was complicated somewhat by the fact that the only data available on hourly population variations (Table 1-5) does not differentiate between central city and urban fringe populations in reporting ratios of people present in each area type. Since failure to make this distinction results in highly unrealistic figures for the total metropolitan population, it is necessary to adjust the calculation procedures to compensate for these differences. In essence, the procedures used merely recognize that hourly population increases in the central city area are made largely at the expense of the urban fringe population at that hour, and that hourly population increases in the urban fringe are made at the expense of non-metropolitan areas and should reflect losses to the central city.

Using the data for 12 noon as an example, the following are the procedures for making actual calculations of hourly population change:

1. Multiply the central city resident population for each area by the ratio of people in the area at the time (see Table 1-5). For 12 noon the census population of residential areas is multiplied by 0.[illegible]8, the population of commercial areas by 5.[illegible]7, and that of industrial areas by 2.46. This yields a central city noontime population of 85 million--about 25 million more than the census figures.

2. Assume the difference between the 85 million in the central city and the 125 million total in the metropolitan area (40 million) to be the number left in the urban fringe; apportion this into the correct percentages for each of the area types (91 percent residential, 6 percent commercial, and 3 percent industrial).

3. Apply the hourly ratios to the corrected population for each area in the same order as step 1 above. This produces the noon-time population of each area type in the urban fringe.

4. Total the central-city and urban-fringe residential, commercial, and industrial area populations for the period (about 129 million in this example). (The excess 4 million over the metropolitan census population is assumed to be from rural and other urban areas. Intuitively, this sum appears far more realistic than does a sum such as the 35 million that would result from not making hourly adjustments to the urban fringe population.)

5. Convert all values to percent of 1966 U.S. population.

POPULATION DISTRIBUTIONS VALIDITY AND RELIABILITY

The end products of these steps are the 24-hour series of population distribution estimates in Tables 1-7 and 1-8. The fact that they are only applicable to metropolitan areas limits their usefulness to some extent but by no means completely. As shown in Parts Two and Three of this report, outdoor warning facilities are best evaluated only in the metropolitan environment. Also, having a point of departure makes it possible to introduce other corrective factors to expand the usefulness of these estimates.

However, as always, questions relating to the validity and reliability of these estimates can be recognized and--hopefully--answered. First, these estimates cannot possibly be completely valid or completely reliable. Population movements

Table 1-8. Metropolitan Population Distribution (in Percent) Estimates for U.S.--1966 Central City and Urban Fringe Combined

TIME	PERCENT IN METROPOLITAN RESIDENTIAL AREAS	PERCENT IN METROPOLITAN COMMERCIAL AREAS	PERCENT IN METROPOLITAN INDUSTRIAL AREAS	PERCENT OF TOTAL
1 AM	55	6	4	65
2	56	6	3	65
3*	56	6	3	66
4	57	6	3	66
5	57	6	3	66
6	56	6	3	65
7	54	7	5	66
8	46	11	6	63
9	41	19	6	66
10	37	23	6	66
11	35	26	6	66
12	35	26	6	66
1 PM	34	26	6	66
2	33	28	6	66
3	32	28	6	66
4	34	26	6	66
5	39	22	5	65
6	48	12	4	63
7	49	10	4	63
8	46	13	4	63
9	47	13	4	63
10	49	10	4	63
11	50	8	4	63
12	54	7	4	63

Key:

*Approximate census--resident population of area.
**Row totals may reflect rounding errors.

(as with most human behaviors) are subject to influence from a number of factors, some of the most predictable of which--holidays, weekends, seasonal changes, etc.--could not be accommodated within the findings of this study. Less predictable events such as an epidemic of sickness, a heat wave increasing use of resort facilities, or even politically inspired absenteeism, etc., further limit the validity of these estimates.

Conversely, these estimates reflect a few behavioral events accounting for a large portion of the total time-related behavior of the population. Attending school or work occupies some period of time for a large segment of the population, at least most of the year. Similarly, shopping, while comprising a dynamic series of events, causes people to be located in areas other than their homes and regularly occupies some time for some people. Also, being at home is a regular event for most people at least for part of the time. When the portion of the population likely to be engaged in one of these regular events is considered, the irregular events seem to diminish in importance. So while there are omissions in the estimates--some taking on major proportion at particular times--the likelihood is that a great deal of the movement of people in a 24-hour period is reliably accounted for by these findings.

Although no stretch of the imagination would allow a claim of absolute validity for the findings, there are reasons for believing that they are relatively valid. First, by inspecting Table 1-7, it is difficult to find anything to challenge the credibility of the data. The numbers rise and fall more or less in accord with what one would anticipate, given a knowledge of the area types. There seems to be little to quarrel with in the numbers of people in each area, unless one is disturbed by the low numbers found in the industrial areas. It should be remembered that several major industries (mining, lumber, iron and steel production, textiles) tend to operate facilities in relatively small, single-purpose towns. These towns and industrial facilities are frequently outside the area included in a census-defined Standard Metropolitan Statistical Area (SMSA) and are seldom large enough to qualify as SMSAs themselves.

Although the actual distribution of workers in such locations is not available, it seems reasonable to assume that if their numbers were known the distribution of people in metropolitan industrial areas would appear even more reconcilable with the intuitively expected numbers.

PART TWO: WARNING SYSTEMS EFFECTIVENESS

ANALYTICAL FRAMEWORK

The overall objective of this study is to develop methods for determining the optimum mix of warning facilities, where total system effectiveness is defined in terms of population coverage and speed of dissemination. To accomplish this goal some preliminary requirements must first be met. First, the particular warning facilities that might make up an optimum mix should be determined. To some extent this was given, insofar as there was no point in considering facilities not directly linked to system effectiveness (i.e., as defined in the contract scope of work), or for which there were no data available. This immediately eliminated from further consideration systems or facilities used exclusively for distributing warning to nonpublic termini, i.e., the National Warning System (NAWAS), the Decision Information Distribution System (DIDS),[1] and the Emergency Action Notification System (EANS). Short of making system terminals directly available to the public, changes to these facilities will not change population coverage or speed of dissemination. It is recognized, however, that such distribution systems exercise a major influence on total system effectiveness--but only as they work, or fail to work, in initiating the start of the process of warning the public. For example, should the EANS system fail to work, it is clear that the activation of the Emergency Broadcast System would be much slower than it would be otherwise, but once activated, EBS itself would operate at its peak effectiveness level for the time period. At the time this report was written, data was not available from field tests being conducted by OCD on DIDS home alert receivers, or by FCC on NIAC alert receivers. Such data should be considered as it becomes available.

[1]Although DIDS is considered here as a distribution system, it is capable of being extended for local warning into individual homes.

Four warning facilities were directly tied to warning effectiveness and also had sufficient data available to complete the analysis: outdoor warning systems, the Emergency Broadcast System (in a crisis), the Crisis Home Alert Technique (for television), and telephone warning systems.

Having selected the warning facilities for which further analysis was indicated, some means of putting them on the same evaluative footing was required. These evaluative criteria were also largely dictated by the project objectives. That is, if total system effectiveness was tied to measures of coverage and speed of dissemination, then these same measures were required for each warning facility being considered for the optimum mix.

Three basic groundrules were formulated for these measures:

1. Report measures of population to the nearest million, rounding upward on 0.5 million or more.

2. Report calculations of warning dissemination time only to a maximum of 30 minutes and in shorter increments when possible.

3. Use conservative estimates except for warning dissemination start times, for which assume that all system warning begins at time zero.

The actual procedures used to obtain measures of population coverage and speed of dissemination varied with the specific system. Descriptions of each system and the procedures used to obtain these effectiveness parameters constitute the bulk of the following sections. Effort is not made to evaluate any system in this part of the report, but rather to describe the reasoning and data used in Part Three as inputs to the determination of an optimum mixture of systems, facilities and techniques.

OUTDOOR WARNING SYSTEMS

SCOPE

The rubric "outdoor warning" almost defies description. It covers an incredibly wide range of facilities, techniques and systems--some of which function as warning devices only by dint of being activated at some unusual time (should warning be required at exactly 12 noon on a weekday, for example, a good many workers and school children may be delayed in their understanding of the situation because they were expecting a luncheon signal at the time). Because so many agencies and even individuals use such a wide variety of devices for different purposes, an attempt to do anything more than simply list the major outdoor warning facilities would exceed the scope and time limitations of this project.[1]

Sirens are the most familiar of the outdoor alerting devices and are found serving different primary functions for police, fire, civil defense, other government agencies and at industrial plants, factories or workyards. In case of national emergency it is expected that government and private firms alike will use their sirens to alert those within range of the danger. Considering the wide variability of such aspects as sound level outputs, mobility, population likely to be within range, and number of sirens available, it is clear that obtaining truly accurate measurements of coverage or speed of dissemination is exceedingly difficult.

A similar difficulty exists in gathering information on the effectiveness of loudspeaker systems. The range of applications is as wide as for sirens, being

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[1] A large number of sources are available for those interested in exploring further the range of outdoor warning facilities. Among the most comprehensive: R. L Lamoureux and J. O. Neilson, Improved Outdoor Alerting and Warning, op cit.; R. L. Lamoureux, et al., Emergency Operating System Development (EOSD) Project Warning Task (65-1) Phase I, SDC, TM-L-2454/001/00 (Draft), October 1965; Special Projects Staff, Civil Defense Warning Requirements Study, SDC, TM-L-900/001/01, January 1963; A. E. Bornstein, et al., Warning Systems Research Support, SDC, TM-2870/020/01, November 1966; and P. H. Kutchenreuter, et al., A Proposed Natural Disaster Warning System, Department of Commerce, October 1965.

found on emergency vehicles (ground and air) and at almost all outdoor recreational locations, and serving as municipal warning systems and commercial/industrial paging systems.

A third category of outdoor device is the pyrotechnic flare. Most often pryotechnic devices are intended to be launched into the air by rocket or hand-held flare guns. Some are accompanied by an explosive burst or whistle as an attention device or adjunct to the visual display. The pyrotechnic devices are relatively rare, being most commonly used for military search and rescue or as roadside warning of a temporary hazard. It is possible that certain communities still retain some experimental wide-area warning devices, but these are thought to be very few.

A final category, best labeled "other" outdoor devices, must include signal flags, flashing lights, church bells and one-of-a-kind devices where the interpretation is more important than the device itself. For example, continuously sounding an automobile horn for a minute or so is generally uncommon and will attract attention whenever it occurs. Even on an unprepared population then, a car horn could be used as an alerting device. If a group agreed to a common interpretation to such a sounding, the horn would serve a warning function as well as an alerting one.

It should be clear from this cursory review of outdoor warning devices that any analysis of "system" effectiveness must be based on very general data. The extreme variation in controlling agencies, device coverage and attention-getting capabilities constitute only a fraction of the complexities within the outdoor warning system; including population preparedness, disaster experience, and confidence in the system as variables would provide a better--but still incomplete--picture. If it were possible, accounting for on-going changes to the system would be required before a perfectly valid analysis could be complete. The measurement problem attendant to these complexities is equally insolvable. At the present time there appears to be no feasible way of obtaining empirical measurements of these many variables. Even if a survey

of all agencies and firms using such devices were undertaken, there is no way to account for individual or informal group warning plans, or for such spontaneous alerting tactics as mass blowing of horns or firing of the town cannon. It is because of this complexity and variety that warning analyses usually decide to select a well-defined outdoor alerting device and analyze its effectiveness. There is only one device really amenable to quantified analysis: sirens paid for by OCD and matching community funds. Although this yields a fairly accurate picture of the alerting capability of these units, it ignores the vastly larger number of other outdoor devices, including the sizable number of sirens not paid for with OCD funds.

There is, of course, no really good solution to these problems. Although a number of previous studies[1] were examined in the course of this project, the same basic weaknesses were found in each. Rather than go over the same ground (and fight the same battles), a decision was made to let the estimates of local CD officials stand as the definitive word on the status of outdoor warning. These estimates are regularly provided to OCD through the Integrated Management Information System (IMIS). The instructions for preparing the relevant portion of the IMIS program papers and progress reports state that the CD Director must understand that:[2] "Outdoor Warning System means any method used locally to get outdoor warning to the public (e.g., CD sirens, industrial sirens or whistles, air horns, expedient means such as use of sirens on fire trucks, etc." for the purpose of estimating the population covered by outside warning.

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[1] R. L. Lamoureux and J. G. Neilson, op. cit.; R. L. Lamoureux, et al., op cit.; Special Projects Staff, op. cit.; A. E. Moon, Population in Shelte , Stanford Research Institute Project No. MU-5071, November 1965; C. B. Dobbins, A Preliminary Analysis of the Warning System, Office of Civil and Defense Mobilization, Operations Research Office, OCDM-SA-60-4RM, June 1960; and R. A. Harker, R. L. Goen and K. D. Moll A Method for Evaluating Local Civil Defense Effectiveness, Stanford Research Institute, Project IM-4970, October 1964.

[2] OCD, Federal CD Guide, "Local Civil Defense Program Papers and Progress Reports for Fiscal Year 1969," Part B, Ch. 3, App. 2, April 1968, p. 20.

Population coverage estimates provided in the local program papers are based on the same definition of outdoor warning used in this project. Since these program papers are the only known source of data collected on-site by people familiar with the environment (for all the intuition that must go into their preparation), these estimates are the closest approximations of outdoor coverage that can currently be obtained.

The following section makes full use of these estimates in the calculation of outdoor warning effectiveness. The actual measure used is the national summary value of 64.7-percent coverage as of June 1969.[1] This represents the average of 4384 separate local program papers and the Bureau of Census estimates of current population. The procedures and findings are described in detail below.

OUTDOOR WARNING EFFECTIVENESS

The analysis of system effectiveness for outdoor warning and for every other system treated in this report, requires two discrete sets of information: a rate of alert or warning dissemination, and the population covered or served by the system. Using these two sets of data it is a simple matter to determine the effectiveness of the system over a specified period of time. Depending on the amount of confidence placed on the data, the preceding statement is more or less true. If the data are the best available, then one is well advised to make the determinations and proceed with the work at hand; if, however, it is possible to account for important variables not reflected in the primary data without creating a "credibility gap" in the process, then the work demands that be done as well.

[1] Civil Defense Program Status and Progress Summary Report, National, OCD Form 744B, June 1969, p.1.

For the analysis of outdoor warning effectiveness the latter situation occurred. The population coverage data was obtained from the National Civil Defense Program Status and Progress Summary Report, and was represented as being 64.7 percent (rounded to 65 percent) of the population. No time limit or period was placed on this estimate and CD Directors might as easily have used 30 hours as 30 minutes in making their individual inputs. It was necessary to search the literature for additional information on the speed of outdoor alerting dissemination.

Although it was not possible to obtain the original document, several secondary sources reported on a most relevant study by Elihu Katz of the 1959 air raid false alarm in Chicago.[1] The event leading to the activation of the CD sirens was the success of the White Sox in winning the American League Championship. In the excitement over the event, the sirens were ordered turned on for a 5-minute period. Katz found that those knowing of the siren's sounding within the first 5 minutes were about 20 percent, which increased rapidly through the following 10 minutes, reaching about 75 percent of those who were ever aware within that period. By 30 minutes, the proportion reached 97 percent. Although it was not possible to locate any other study providing comparable dissemination estimates, these data were partially supported by other related studies. An example was the Bosak, et al.[2] report on a siren false alarm in Concord, California, where 75 percent of the sample recognized the sirens as related to civil defense and 85 percent of the sample sought additional information. The sirens sounded

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[1] Elihu Katz, Joy in Mudville, National Opinion Research Council, University of Chicago, June 1960. The figures were reported in A. E. Moon, op cit., p. 50. Other sources include Harker, Goen, and Mall, op. cit., T. Wang, et al., Air Raid Warning in the Missile Era, Operations Research Office, Johns Hopkins University, July 1960, pp. 34-35.

[2] N. Bosak, et al., Warning System Research Support: Concord Study, SDC. TM-2870/010/01, June 1966, p. 7.

for an hour in the Concord case, which indicates that of those able to hear the outdoor warning system, 85 percent would have been warned within an hour if they had obtained the information they sought. Just how rapid the actual dissemination was in Concord is not known. However, in a more recent study of Detroit, Lamoureux[1] estimated the time it would take for 95 percent of the population within specified siren coverage patterns to detect the signal. Depending on the loudness level and distance, his most optimistic set of estimates varied from 2.5 minutes to 15 minutes and his most pessimistic estimates from 7.5 minutes to 25 minutes.

When the Chicago findings are applied to the 1966[2] census data and the 65-percent coverage factor is accounted for, the hypothetical outdoor warning system effectiveness is:

0-5 minutes--25 million alerted
0-15 minutes--109 million alerted
0-30 minutes--122 million alerted

The term "hypothetical" may be too affirmative, as the estimates seemingly are very optimistic. As a preliminary step to achieving a more realistic measure of effectiveness, the nonmetropolitan population should be removed from consideration. The reasoning is that all data relating to speed of dissemination were obtained from metropolitan areas. Considering differences between metropolitan and nonmetropolitan environments in terms of outdoor alerting capabilities, using the same rate of dissemination for both is unjustifiable. When the nonmetropolitan population is removed from the analysis, the results (shown in Table 2-1), appear somewhat more reasonable. These data were derived from the

[1] R. L. Lamoureux, Warning Considerations for the Detroit Tunnel-Grid Blast Shelter Concept, Oak Ridge National Laboratory, TM-1719, March 1967, p. 31.

[2] Used for consistency with other calculations.

Table 2-1. Theoretical Maximum Outdoor Alerting in Metropolitan Areas--100 Percent Effectiveness for Those Covered in Millions Alerted*

TIME	POPULATION IN METROPOLITAN AREAS	WITHIN SIREN COVERAGE	ALERTED 0-5 MIN	ALERTED 0-15 MIN	ALERTED 0-30 MIN
1 AM	126	82	16	61	79
2	126	82	16	61	79
3	126	82	16	61	79
4	126	82	16	61	79
5	126	82	16	61	79
6	126	82	16	61	79
7	126	82	16	61	79
8	123	90	16	60	78
9	127	82	16	61	79
10	129	83	17	62	81
11	129	83	17	62	81
12	129	83	17	62	81
1 PM	129	83	17	62	81
2	129	83	17	62	81
3	128	83	17	62	81
4	128	83	17	62	81
5	126	82	16	61	79
6	122	79	16	59	77
7	122	79	16	59	77
8	122	79	16	59	77
9	123	80	16	60	78
10	123	80	16	60	78
11	123	80	16	60	78
12	123	80	16	60	78

*Uses OCD 1969 outdoor coverage estimates of 65 percent and does not compensate for probable differences in response due to sleeping, population outdoors, and ambient noise variations.

hourly population estimates for metropolitan areas in Table 1-7 and take into account the 65-percent coverage factor and the Chicago rates of dissemination. Thus, in 5 minutes time the warning had reached 30 percent of those covered by some kind of outdoor warning. In 15 minutes the proportion had climbed to 75 percent of those covered and in 30 minutes, 97 percent are warned. As the population in the metropolitan area rises and falls from the census base data, the number warned also varies. Even when the outdoor warning effectiveness estimates are adjusted for the lack of data on nonmetropolitan areas, there is still some question as to their validity. Specifically, the estimates make no allowances for the variability in outdoor warning effectiveness brought on by changes in the ambient noise conditions present in the environment; changes in the proportion of people likely to be outdoors; and changes in the wakefulness of the population. Furthermore, these variables are not accounted for within the particular setting in which they occur, i.e., in metropolitan, residential, commercial, and industrial areas.

To illustrate the nature of these factors in terms of their consequences to the preceding estimates, consider the case of late-night alerting and warning. In contrast to the situation obtaining during the Chicago false alarm (which occurred at 10:30 PM, the qualitative assessments in Table 2-2 show that most of the population will be at home, asleep. Even though the ambient noise is lower at night, the difficulty in penetrating the sleeping quarters with a signal from outside would almost cancel the advantage. Waking the sleepers is quite a serious problem,[1] one that has yet to be solved by outdoor warning systems. The overall effect of these conditions is almost certain to be a deterioration in effectiveness, a result not changed by the fact that very few

[1] For a comprehensive review of the difficulty of arousing a sleeping population, see B. D. Miller, Optimum Response to Alerting Signals and Warning Messages, SDC, TM-L-3876,003/01, March 1969, p. 133 ff.

Table 2-2. Qualitative Assessment of Outdoor Warning Effectiveness Variability in Metropolitan Areas

RESIDENTIAL	AMBIENT NOISE	POPULATION OUTDOORS	POPULATION SLEEPING	ESTIMATED NET EFFECT	COMMENTS
11-6 AM	+	-	-	-	Normal sleeping hours.
6-9 AM	-	+	-	-	Transitional period from sleep.
9-4 PM	+	+	0	+	Increased outdoor movement.
4-7 PM	-	+	0	0	Traffic noise.
7-11 PM	0	0	0	0	Baseline hours.
COMMERCIAL					
11-6 AM	+	-	-	-	Normal sleeping hours.
6-9 AM	-	+	0	0	High ambient noise level cuts effect.
9-4 PM	-	+	0	0	Large numbers outdoor could be a plus.
4-7 PM	-	+	0	0	People in transit.
7-11 PM	0	0	0	0	Baseline hours.
INDUSTRIAL					
11-6 AM	+	-	-	-	Normal sleeping hours.
6-9 AM	-	+	0	0	Traffic noise cuts into effect.
9-4 PM	-	0	0	-	Industrial noise cuts into effect.
4-7 PM	-	+	0	0	Traffic noise.
7-11 PM	0	0	0	0	Baseline hours.

Key:

\+ Predicted improvement to siren effect
0 Predicted no change
\- Predicted reduction to siren effect

Source:

Assumed for the reasons indicated in "comments."

people are likely to be outdoors. This assessment would probably hold true (with only slight differences to account for nightshift workers) in the commercial and industrial areas as well as purely residential areas.

The assessments in Table 2-2 further show how this negative net effect continues in the residential area until after the major movement to school and work is completed, due to the combined effect of some people still being asleep and higher ambient noise level associated with traffic. In the commercial and industrial areas the large numbers in transit and outdoors should bring the net effect into parity with the evening hours effectiveness. The effect of conditions during the 9 AM-to-4 PM period in the residential areas would be a general increase in effectiveness as the ambient noise will be lowered and people will be outdoors and otherwise more exposed to outside signals (especially in warm weather, when doors or windows may be open). The prevailing conditions in commercial areas would yield a neutral net effect, with possibly a slight edge to the positive side because of the large numbers outside. Of course, the high ambient noise levels will reduce any improvement caused by the population being outdoors. During this period, industrial areas would probably have no major increase in the number outdoors and effectiveness would suffer from the high noise levels, making it more difficult to hear an alerting signal. In the period just before the hours on which the rates were based, a neutral net effect is shown for all three areas. Because this is a period of mass movements from work to home, a large number of people will be outdoors or otherwise accessible to outdoor warning, (e.g., in cars with windows open, etc.). However, the increase in noise will probably neutralize those gains and, since few are sleeping at this time, result in an effectiveness level about equal to the baseline hours.

Viewed from a logical/qualitative perspective then, it appears that some adjustments to the preceding outdoor warning system effectiveness estimates are in order. While the fairest adjustment might be to add some directional indicator

to those estimates showing that "the same" or "less" than the stated number will actually be warned, such qualitative indices are hardly better than Table 2-2. In the long run it is probably better to take the chance of arbitrarily assigning quantities to the net effect qualities and hope that an educated guess is an improvement on no guess at all. While this may not be a very satisfactory solution, the unadjusted figures are presented in Table 2-1 and can be used in lieu of the adjusted data, if desired.

The values in Table 2-3 are the quantitative estimates of magnitude for the qualitative effects described previously. The numbers are the percentage points of change in the direction indicated. Hourly increments were chosen over the larger periods used in the preceding table so that gradations of change could be shown rather than large, sudden jumps. Using the hour interval also facilitates subsequent computations. In interpreting these values it should be remembered that they represent percentages of changes from the total warned within 30 minutes at 10:30 PM in Chicago. Thus, where the Chicago rate was 97 percent in 30 minutes, the residential area percentage warned would be an estimated 92 percent at the same time--the difference being to allow for time zones and personal preferences in the time of retiring for bed.

With these adjustment factors in hand, it is a simple matter to compute a better approximation of outdoor warning system effectiveness--or at least one that accounts for some of the more obvious variables. The actual procedure requires first that all metropolitan population data in Table 1-7 be converted to reflect the number within the coverage of some outdoor warning system. This is accomplished by multiplying each population value by 0.65 (the OCD Outdoor Warning System Coverage estimate). Next, add or subtract (as indicated in Table 2-3) the hourly area adjustment factor to the Chicago rate for 5-, 15-, and 30-minute intervals, i.e., add to or subtract from 20, 75, and 97 percent, respectively, the correct value for the area type and hour being computed. This provides an adjusted dissemination rate which can easily

Table 2-3. Quantitative Assessment of Outdoor Warning Effectiveness Variability in Metropolitan Areas—in Percentage Shift

TIME	AREAS		
	RESIDENTIAL	COMMERCIAL	INDUSTRIAL
1 AM	-20	-20	-20
2	-25	-20	-25
3	-30	-25	-30
4	-30	-30	-25
5	-25	-25	-20
6	-25	-20	-15
7	-20	-15	-15
8	-10	-5	-15
9	-5	0	-10
10	0	0	-10
11	+5	+5	+0
12	+15	+10	+5
1 PM	+15	+5	+0
2	+15	0	-10
3	+10	0	-15
4	+5	0	-10
5	0	0	-5
6	0	0	-0
7	0	0	0
8	0	0	0
9	0	0	0
10	-5	-5	-5
11	-10	-10	-10
12	-15	-15	-15

Source:

Assumed, based on qualitative assessment in Table 2-2.

be converted into the number alerted within that area and time interval. To do so requires only that one multiply the adjusted rate times the number calculated to be within coverage of the outdoor warning system.

The process is simpler than it reads. Using 12 noon as an example, the adjustment factors and the number within outdoor warning coverage, respectively, are:

Residential Areas + 15 percent, 44 million
Commercial Areas + 10 percent, 33 million
Industrial Areas + 5 percent, 8 million

Adding the adjustment factors and Chicago rates we have:

	Number Covered	Percentage Alerted In: 0-5 Minutes	0-15 Minutes	0-30 Minutes
Residential	44	35	90	100 +
Commercial	33	30	85	100 +
Industrial	8	25	80	100 +

When the population numbers are calculated from these percentages, the tables for each time period can be combined to indicate the number warned in the metropolitan area within the interval.

This procedure describes how the system effectiveness estimates in Table 2-4 were derived. In rechecking some of these values it was noted that they do not always amount to the expected number. The differences are relatively minor and are accounted for by the various roundings off of numbers undergone by the data since early computations were completed.

It is of some interest to note that, compared to the Table 2-1 estimates, the major impact of these various adjustments for noise, sleep, and outdoor population has been to show late night, early morning losses and midmorning,

Table 2-4. Cumulative Outdoor Alerting for Metropolitan Areas at 5-, 15-, and 30-Minute Intervals--in Millions Alerted

	RESIDENTIAL			COMMERCIAL			INDUSTRIAL			METROPOLITAN TOTALS		
	0-5	0-15	0-30	0-5	0-15	0-30	0-5	0-15	0-30	0-5	0-15	0-30
1 AM	-	38	53	-	5	6	-	3	3	-	46	62
2	-	35	51	-	5	6	-	2	3	-	42	60
3	-	32	47	-	4	5	-	2	3	-	38	55
4	-	29	48	-	3	5	-	2	3	-	34	55
5	-	36	51	-	4	5	-	2	3	-	42	59
6	-	36	51	-	4	5	-	3	3	-	42	59
7	-	37	52	1	5	7	-	3	5	1	46	64
8	6	35	51	2	10	12	1	5	6	8	49	59
9	8	36	46	5	18	23	1	5	7	13	59	75
10	9	35	46	6	22	29	1	5	7	15	57	74
11	11	35	44	8	26	33	1	6	8	20	61	76
12	13	39	44	10	28	33	2	7	8	25	73	85
1 PM	13	38	43	8	27	33	1	6	8	23	71	84
2	14	38	42	7	25	33	1	5	7	22	68	81
3	12	35	41	7	25	33	1	5	6	20	65	80
4	11	34	43	7	25	32	1	5	7	18	64	81
5	10	36	47	5	21	27	1	4	5	16	61	79
6	12	43	59	3	10	13	1	3	5	16	57	77
7	12	44	60	3	9	12	1	3	5	16	56	76
8	12	44	57	3	12	16	1	3	5	16	60	77
9	12	44	57	3	12	16	1	3	5	16	60	77
10	9	44	57	2	9	12	1	3	4	12	56	72
11	7	42	55	1	7	9	1	3	4	8	51	68
12	3	40	55	1	5	7	-	3	4	4	48	66

Source:

Uses OCD outdoor coverage estimate of 65 percent and assumed adjustment factors to compensate for probable differences due to sleeping, population outdoors, and ambient noise variations.

Key:

- Fewer than 1 million

early afternoon gains to the outdoor warning system effectiveness. A less significant consequence has been to slow the overall rate of warning dissemination, although the 30-minute totals in Tables 2-1 and 2-4 are quite close. Both phenomena seem, intuitively at least, to be fairly reasonable and probably not far from correct. The lowered numbers reached late at night are indicative of the fact that it may prove very difficult to arouse sleepers with an outdoor signal. The daytime increases in effectiveness reflect the greater number of people outside during these hours.

EMERGENCY BROADCAST SYSTEM (EBS) AND CRISIS HOME ALERT TECHNIQUE (CHAT)

SCOPE

The major purpose of the Emergency Broadcast System (EBS) is to provide the Government with a means of immediately communicating with the public during and after an "Emergency Action Condition."[1] Since such hazardous conditions include the prospects of a national crisis or war, EBS can fulfill an alert and warning function as well. EBS exists as a voluntary association of private broadcasters under the control of the Federal Communication Commission (FCC) assisted in a planning capacity by the National Industry Advisory Committee (NIAC). Operationally, the system comes under the control of the President of the United States and will be used by other Federal, regional, state or local authorities or organizations on a planned basis, subject to Presidential priority.

While the EBS is activated, it comprises four classes of station participants: 1) stations possessing a National Defense Emergency Authorization (NDEA) and designated as the primary broadcast station for their operational areas (these stations have the responsibility of broadcasting EBS programming directly to the public); 2) stations with NDEAs, but not designated as primary, to standby as alternate stations and take over EBS programming should the primary stations go off the air; 3) stations with the NDEAs serving as primary relay stations

[1] Basic Emergency Broadcast System Plan, FCC, OCD, and OEP, FG-E-4.1, August 1967, p. 1 and p. 27.

to rebroadcast programming materials intended for the use of stations in the first two classes (these are normally FM broadcast stations functioning together as an off-the-air pickup network for disseminating state-, region-, or Federal-level programming to the operational area stations for rebroadcast at the same time or a later time); 4) stations with NDEAS serving as alternate relay stations to resume broadcasting if the primary relay station discontinues operations for any reason. Broadcasting stations unable to qualify or unwilling to apply for NDEAs are required to terminate all broadcasting activities during the operation of EBS. Prior to doing so, however, these stations must discontinue normal broadcasting and deliver a prepared EBS warning message. This ensures that every station, whether it is scheduled to participate further or not, tries to attract the attention of all members of the audience and provide them with warning.

EBS activation is by the Emergency Action Notification System (EANS). The EANS uses any of four techniques to distribute the activation message--use of any one of which is sufficient to cause broadcast stations to assume the appropriate emergency postures. The distribution techniques are 1) by automatic selective switching equipment at Associated Press (AP) and United Press International (UPI), which routes the EANS message to all AM, FM, TV and other stations subscribing to the radio wire-Teletype services; 2) by the dedicated teletypewriter network to selected control points of the commercial radio and television networks and then through internal network alerting facilities to participating stations; 3) through off-the-air monitoring, as required by FCC rules of other stations, so that stations not contacted by techniques 1 or 2, above, will receive the EANS message; and 4) over off-the-air monitoring by the general public, who are listening or viewing other stations and then evidently inform any station not learning as a result of techniques 1, 2, or 3, above.[1]

[1] Ibid., pp. 35-36. Reference is also made to a muted receiver still being tested. Note that this method is rather vaguely stated in the EBS plan and may not involve any communication from the public. If not, some further clarification would be helpful.

Although test data are not reported, the EBS is regularly exercised and the industry is evidently confident of being able to activate the system within 5 minutes under the worst circumstances.[1]

The EBS, however, is completely dependent on the listening and viewing habits of the public for its effectiveness. As observed earlier and shown in Table 1-4, the measured mass media audience (radio and TV) drops to a low of 9 million people at 2 AM, after which the measuring services do not report any figures until 6 AM. Under certain circumstances, however, this limitation could be minimized or perhaps eliminated. Specifically, during a national crisis such as occurred in 1961 over the Russian missiles in Cuba, it is expected that public concern and interest will be attuned to the danger of war and focused on the mass media. At such a time the audience would be increased somewhat at all hours and, with a minimal effort on the part of broadcasters and government, a huge audience increase could be obtained in the late-night-through-early-morning hours.

The technique is called the Crisis Home Alert Technique (CHAT)--a somewhat misleading acronym since there is no "chatter" associated with the situation or the technique. As CHAT is currently envisioned,[2] it will be a special operating mode of EBS which uses the facilities of major market area television stations for late night warning during national crisis situations. CHAT-TV, as it is now called, will operate between 11 PM and 7 AM by having selected stations in the 224 market areas terminate aural broadcasting during

[1] Indicated in Ibid., "Statement of White House Requirements," p. 14.

[2] This discussion is based on the mode first advanced by Robert B. Martin, Staff Director, OCD Communications-Electronics Division in 1965 and described in B. D. Miller, Crisis Home Alert Technique (CHAT) Development Project, SDC, Draft TM-L-3390/003, September 1967, p. 20 ff. Subsequent investigations of CHAT-TV development have been channeled into this direction, according to R. L. Crosby, "Crisis Home Alerting Technique Project Monthly Progress Report," SDC, TM-L-4373, August 1969, p. 3.

the period, while continuing to transmit the aural carrier signal at zero modulation and a video signal the content of which is as yet unspecified.[1] This allows the audience to select the CHAT-TV station before, at, or after 11 PM. As soon as the station enters the CHAT mode, they can turn the audio/volume control up to what would normally be very loud without being bothered by receiver or atmospheric noise or program material. This will allow the audience to sleep until the station resumes modulating its audio signal--at 7 AM or to deliver a warning message. In the former case the modulation is to be gradually increased; in the latter, the more startling the return to audible broadcasting the better.

EBS AND CHAT-TV EFFECTIVENESS

Establishing effectiveness measures for EBS and its nighttime warning mode, CHAT-TV, is a relatively straightforward problem, complicated only by the fact that the CHAT concept requires a crisis to be implemented. Since a crisis would increase the effectiveness of any warning system, particularly those requiring public participation as do EBS and CHAT, there are actually three major conditions: EBS effectiveness where the public is unprepared; EBS effectiveness where a national crisis commands public attention; and CHAT-TV, which can only occur during such a crisis.

In each case, since there are no empirical EBS or CHAT performance measures, three major assumptions are made: (1) the measured mass media audience at any given time is a conservative estimate of the audience that would be available for EBS or CHAT warning at a comparable time; (2) the rate of disseminating news of an attack will be the same as the rate for other high

[1] A display panel was suggested by Miller, op. cit., p. 113, but will probably prove too lengthy for accurate resolution by cameras or transmission and reception facilities.

saliency news and the rate for each medium is fixed, regardless of the time of occurrence; and (3) those not in the measured audience of the media are potential recipients of telephone calls or face-to-face contacts.

The similarity of these assumptions and measures to those used in establishing the Standards of Warning Effectiveness, described in Part One, is deliberate. Actually there is only one discernible difference in the conditions, actions, and system responses undergone by the mass media during the Kennedy assassination and those required for EBS activation: no EAN message was distributed over the AP/UPI or network connections. The effect this would have had on the dissemination of the news is unknown, but it may have been modest. It seems, for example, that all stations (radio and TV) tied in to network lines were made aware of the event over those lines about as quickly as they would have been via EANS. Other stations also picked the news off the AP/UPI lines or other sources without noticeable delays.

There appears to be no practical means of dealing with whatever differences exist between the effectiveness of EBS in warning an unprepared population, and the effectiveness of the media and the public in disseminating news considered very important--both personally and politically. For the purposes of this report then, the two phenomena can be considered equivalent. While there are many arguments--practical and philosophical--for opposing this position, it appears to be the only solution that stays within bounds for the available data and provides a conservative estimate of system effectiveness.

Since EBS effectiveness and standards are equivalents, it would be necessary to use the same data and the same procedures--and obtain the same results in both cases. There is, then, little to be gained by relabeling Table 1-4 and inserting it below; there is even less point in pursuing the issue further (in Part Three) by comparing the same data to optimize system operations.

Both EBS and CHAT-TV warning, depending as they do on the media usage habits of the public, will gain in effectiveness as the habits of the public change to show an increase in media consumption. Such increases are expected to occur during a national crisis, based on experience gained during major news events where it was possible to inform the public in advance. The changes in audience size during these advance-notice news events have been measured and these measurements constitute the most reliable source materials upon which to base crisis-related measures of EBS and CHAT-TV effectiveness. The best measured and reported event in recent times was the Apollo 11 "walk on the moon" mission. During those 9 days (July 16 through July 24) public interest was nearly at an all time high, and audience figures increased accordingly. Because the mission took place over an extended period and there were several particularly interesting features scheduled, it was possible for the A. C. Nielsen Company to gather audience measures for several different time periods of the same basic event.[1] The increases over the audience normally viewing television at each time were sizable, reaching a high of 34.8 million households--almost 64 percent of those with television sets in the U.S. at that time.[2]

Although other studies were available and were reviewed for this project,[3] the Nielsen figures provided the most complete appraisal of the change in audience that occurs during a well-publicized major event. These data were

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[1] These data were reported in "Apollo 11 Turns Out as Biggest Show on Earth," Broadcasting, September 1, 1969, p. 50.

[2] Another report gave a total of 125 million viewers for the moon walk, Broadcasting, July 28, 1969, p. 28.

[3] S. P. Spitzer and N. K. Denzin, "Level of Knowledge in an Emergent Crisis," Social Forces, Vol. 44, 1966, pp. 234-237; I. L. Allen and J. D. Colfax, "The Diffusion of News of LBJ's March 31 Decision," Journalism Quarterly, 45, 1968, pp. 321-6; "TV Good for Informing," Broadcasting, April 21, 1969, p. 9; "Astronauts Top Nixon," Broadcasting, March 17, 1969, p. 10; and "Coast to Coast With Astronauts," Broadcasting, August 18, 1969, pp. 44-49.

used to complete the "Apollo 11 TV Audience" column in Table 2-5. It was necessary to convert the "percentages of households" reported in the study into numbers of people. It was not necessary to adjust these audience figures for time zone, as the events measured occurred only at one time and were not repeated at the same hour in other zones. Also, there were no data available for the 2 AM-to-6 AM period, a fact responsible for the one lapse into educated guesses in this analysis.

As mentioned earlier, the audience measures for the advance-notice news events serve as the source of the crisis-related EBS and CHAT-TV effectiveness measures. The initial step in determining those measures is to combine the Apollo 11 audience with the audience usually listening to radio. With only minor differences, and the audience estimates for the 2 AM-to-6 AM period, this combination serves as the EBS audience estimates. The "minor differences" are slight upward revisions believed necessary to compensate for using radio audience figures undisturbed by the crisis events. The estimated values in the 2 AM-to-6 AM period were chosen to reflect the attrition time would take as people's resolve to sit up through the crisis is affected by fatigue, etc.

Determining the audience available for CHAT-TV was a more complicated operation. A compromise value between the high and low estimates of the television audience at 11 PM in a crisis of 120 million was used as a reasonable (if high) estimate of the number likely to use CHAT-TV each night. Since CHAT-TV is to be operational only in the metropolitan areas, it was necessary to determine the number of potential audience members living in an area where CHAT-TV will be used, i.e., 65 percent of 120 million. This resulting 78 million metropolitan CHAT-TV audience was then normalized to the time zones (described in Part One) to allow for the difference in time (re: EST) at which the system would be activated. This provided the results shown in Table 2-5 as "Estimated CHAT-TV Audience."

Table 2-5. Estimated Effect of Crisis/Special Events on Audiences Available for EBS or CHAT Warning--in Millions

TIME	NORMAL RADIO AUDIENCE	APOLLO 11 TV AUDIENCE	ESTIMATED EBS AUDIENCE	ESTIMATED CHAT-TV AUDIENCE	OTHER CRISIS-TV AUDIENCE	ALL EBS, CHAT RADIO AND TV COMBINED
1 AM	3*	94	97	68	43	114
2	2*	*	50	78	18	98
3	*	*	20	78	7	85
4	*	*	10	78	4	82
5	*	*	10	78	4	82
6	25	*	35	78	12	115
7	47	13	60	38	9	94
8	47	28	75	13	26	86
9	46	42	90	10	38	94
10	42	51	95	NA	53	95
11	39	58	100	NA	61	100
12	36	67	105	NA	69	105
1 PM	33	73	110	NA	73	110
2	31	75	110	NA	79	110
3	31	91	115	NA	84	115
4	33	86	120	NA	87	120
5	35	93	130	NA	95	130
6	33	100*	135	NA	102	135
7	30	115	145	NA	115	145
8	27	115	145	NA	118	145
9	23	115	140	NA	117	140
10	21	115	140	NA	119	140
11	17	125**	140	40	80	137
12	8*	94	105	65	47	120

Key:

* Complete data not available--estimates are probably low

** Uses independent estimate--Broadcasting, 28 July 1969, p. 28

NA Not applicable, as CHAT hours of operation are 11 PM to 7 AM

It is clear, however, that CHAT-TV cannot operate alone. While it may be important to know the theoretical effectiveness of CHAT-TV, it is considerably more important to understand how the system would make its overall contribution to EBS warning effectiveness. To determine this, it was necessary to trace (1) the nonmetropolitan television audience--some 42 million people, and (2) the non-CHAT television audience in metropolitan areas, who in the evenings would still be west of the last time zone where CHAT had been activated, and in the mornings would be those awakened as CHAT-TV went active and who joined the TV audience of their time zone. Thus, at 11 PM EST during a crisis there would be 42 million people living in the nonmetropolitan areas who are still awake and watching television. At the same time, there would be 36 million living west of the Eastern time zone still tuned in to their TV sets. During the period when CHAT-TV is not operating, the crisis TV audience is the same as the EBS TV audience, i.e., the EBS audience without the radio audiences.

A single estimate of the maximum EBS/CHAT-TV warning capability is found in the last column of Table 2-5. These values represent the number of people reached within any given hour over radio and television--the only devices presently used in the Emergency Broadcast System.

Computations of EBS and EBS/CHAT-TV system effectiveness proceed directly from these data, using the same procedures described for Standards of Warning Effectiveness in Part One. Briefly, the procedure is to compute the radio and TV number warned from the dissemination rates for each medium (note that the radio data in Tables 1-4, 2-6, and 2-7 are identical) as applied to the audience at each hour. The potential recipients of either telephone or face-to-face warning (here combined for economy of space and time) are assumed to be those not warned by radio or TV. Thus, the total of those in the radio and TV audience are subtracted from the total population, and the difference is used with the rates of high saliency news dissemination for personal contacts to derive the 5-, 15-, and 30-minute warning estimates for personal sources.

The data used as estimates of EBS effectiveness are the totals for the 5-, 15-, and 30-minute intervals in Table 2-6. The same portion of Table 2-7 provides a similar set of estimates for EBS/CHAT-TV. The idea of constructing a similar set of estimates for CHAT-TV was briefly entertained; however, it was quickly apparent that there was no way to isolate its effectiveness from that of EBS--since the two necessarily interact, if only by virtue of operating in different time zones simultaneously.

TELEPHONE WARNING SYSTEMS

SCOPE

For some time now the prospect of using the facilities of the nation's privately owned and operated telephone companies has been particularly attractive to those concerned with public warning. The major reasons are obvious: existing facilities, wide coverage, rapid operation, and low cost. The fact that the telephone companies have already made the capital investment required to establish a nationwide system of lines, switching equipment, central office facilities and terminal units obviates the need for a major investment by the government. The coverage, in terms of households and businesses reached by telephone, is second only to the broadcast media: of the 57,251,000 households in the U.S., 80.5 percent (46 million) can be reached by telephone.[1] At the time this study was being conducted, the technical feasibility of using the telephone for attack warning had not been fully studied or the speed of operation measured. Since the medium is electrical and may require only minimal human intervention, a warning could theoretically be disseminated to the public nearly instantaneously.[2]

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[1]This may be a conservative estimate, as it considers only households as reported in Current Population Reports, Population Characteristics, Series P-20, No. 146, "Characteristics of Households with Telephones March 1965." Other estimates, more broadly defined, claim as high as 87 percent coverage: Statistical Abstract of the United States 1968, op. cit., Table 731, p. 499.

[2]Data used are from studies made by telephone solicitation firms, University of Michigan and Operations Research, Inc., of the telephone answering characteristics of the public.

Table 2-6. Warning Dissemination Capability of EBS during a Crisis Situation --in Millions Reached

TIME	RADIO			TELEVISION			PERSONAL CONTACTS			TOTAL EBS		
	0-5	0-15	0-30	0-5	0-15	0-30	0-5	0-15	0-30	0-5	0-15	0-30
* 1 AM	1	1	2	45	71	91	16	21	43	62	93	136
* 2	1	1	2	23	36	47	23	31	63	47	68	112
* 3				10	15	19	28	37	76	38	52	95
* 4				5	8	10	30	39	80	35	47	90
* 5				5	8	10	30	39	80	35	47	90
* 6	9	12	21	5	8	10	26	34	70	40	54	101
* 7	16	22	38	6	10	13	22	29	58	44	61	109
* 8	16	22	42	13	21	27	19	25	52	48	68	121
* 9	16	22	38	21	33	43	17	22	46	54	77	127
10	15	20	35	25	40	51	16	21	43	56	81	129
11	14	19	33	29	46	59	15	20	41	58	85	133
12	13	17	30	33	52	67	15	19	39	61	88	136
1 PM	12	16	30	35	55	71	14	18	37	61	85	138
2	11	15	26	38	60	77	14	18	37	62	93	140
3	11	15	26	40	64	81	13	17	35	64	96	142
4	12	16	28	42	66	84	12	16	33	66	98	145
5	12	16	28	46	72	92	11	14	28	69	102	148
6	12	16	28	49	73	99	10	13	26	71	102	153
7	11	15	25	55	87	112	8	11	22	74	113	159
8	9	12	21	57	90	114	[illegible]	11	22	74	113	157
9	8	11	19	56	89	113	[illegible]	12	24	73	112	156
10	7	10	17	57	90	115	[illegible]	12	24	73	112	156
11	6	8	14	59	93	119	9	12	24	74	110	157
*12	3	4	7	47	74	94	15	19	39	65	97	140

Key:

* Data not complete for this period; estimates are likely to be low

Table 2-7. Warning Dissemination Capability of EBS and CHAT-TV during Crisis—in Millions Reached

TIME	RADIO			TELEVISION			PERSONAL CONTACTS			TOTAL EBS		
	0-5	0-15	0-30	0-5	0-15	0-30	0-5	0-15	0-30	0-5	0-15	0-30
* 1 AM	1	1	2	53	84	108	13	17	35	67	102	145
* 2	1	1	2	46	73	93	16	21	42	63	95	137
* 3				41	65	82	18	23	48	59	88	130
* 4				39	62	80	18	24	49	57	86	129
* 5				39	62	80	18	24	49	57	86	129
* 6	9	12	21	43	68	87	13	17	35	56	85	122
* 7	16	22	38	23	36	46	16	21	44	48	69	111
* 8	16	22	42	19	30	38	18	23	47	53	75	123
* 9	16	22	38	23	36	47	16	21	44	55	79	133
10	15	20	35	25	40	51	16	21	43	56	81	129
11	14	19	33	29	46	59	15	20	41	58	85	133
12	13	17	30	33	52	67	15	19	39	61	88	136
1 PM	12	16	30	35	55	71	14	18	37	61	85	138
2	11	15	26	38	60	77	14	18	37	62	93	140
3	11	15	26	40	64	81	13	17	35	64	96	142
4	12	16	28	42	66	84	12	16	33	66	98	145
5	12	16	28	46	72	92	11	14	28	69	102	148
6	12	16	28	49	73	99	10	13	26	71	102	153
7	11	15	25	55	87	112	8	11	22	74	113	159
8	9	12	21	57	90	114	8	11	22	74	113	157
9	8	11	19	56	89	113	9	12	24	73	112	156
10	7	10	17	57	90	115	9	12	24	73	112	156
11	6	8	14	58	91	116	9	12	25	73	111	155
* 12	3	4	7	54	85	109	12	16	33	69	105	149

Key:

* Data not complete for this period; estimates are likely to be low

Once the initial modifications have been made to the existing facilities the cost of operating a telephone warning system would be minimal, as routine maintenance could be performed by telephone company technicians in the conduct of their daily work. Any special line charges associated with maintaining a warning network or links to NAWAS would be modest in comparison to the costs of construction or operating almost any other kind of system.

However, a number of technical and human problems have yet to be solved. For example, at this writing it has not been determined that simultaneous mass ringing of all telephones on a central office switchboard, accompanied by an intelligible voice warning message, is even possible. Also, there is no published description of the procedures (or even the problems) for alerting the 14,000 or so central offices to the need for disseminating warning to the public.

Various schemes for using the facilities of the nation's telephone companies for warning have been under consideration for over a decade. Two approaches are usually suggested: the telephone fan-out procedure, or simultaneous electromechanical activation of most or all sets served by a central office.

The telephone fan-out involves a chain letter-like arrangement whereby the warning is passed by the first person on a list to two or more others by telephone. Each in turn calls a specified number of other people on the list, and so on until all participants have been warned. A telephone fan-out procedure is highly dependent upon every person on the list being available to receive a call and then upon their making the required calls to the next message recipients. Further, because of the inability of most phone systems to handle any more than 15 percent of the subscriber sets being used to originate calls without denying service to others, the geometric progression of phone users during a fan-out would cause the saturation limits to be reached rather quickly, causing delays down the line.

For small systems (such as a rural community) the fan-out may be quite successful, particularly when the message is anticipated or familiar and does not require elaboration or introduce other sources of delay. The procedure seems less well adapted to large systems (as cities) where the increased mobility of the population would probably increase the number of breaks in the warning chains, and the larger numbers would cause more saturation problems for the physical plant of the phone company.

The second procedure, that of disseminating the alert signal and message almost instantaneously from the central office to all (or nearly all) subscriber phones simultaneously, is subject to fewer human factor-types of problems but may be beset by numerous technical difficulties. These difficulties aside (since solving them is not within the province of this study), the central office telephone warning technique is particularly well suited to the urban environment. The particular advantages are associated with the fact that urban areas have the greatest need for rapid warning and this system can achieve that goal. Also, the greater density of population (and telephones) could work to the advantage of the warning, particularly insofar as redundancy of warning increases the likelihood of its credibility.

Considering that information on the number of fan-out phone warning systems is unavailable on a nationwide basis and central office-activated telephone warning appears to offer the greatest payoff in terms of system effectiveness, our focus will be on determining the effectiveness of such a system. In the following analysis it is important to note that there are two major subsets of central office warning: residential and business. The differences are more than academic, as the practical consequences are sufficient to require entirely different techniques for measuring the separate contributions of each to total system effectiveness. Because of their different "characters," a brief description of each precedes the analysis of their combined effectiveness.

Residential Telephone Warning

Use of the existing telephone systems to effect warning of the residential population appears to offer the opportunity for a spectacular increase in warning effectiveness. The speed of operation--in terms of time required to answer a ringing telephone--is remarkably brief. Studies have shown that calls made at night are responded to within a minute or less, 90 percent of the time.[1] The response rate during the day is probably about the same. Professional telephone researchers usually allow about 5 rings (30 to 35 seconds) before giving up on a call.

Telephone residential coverage is equally impressive. There were almost 43 million main residential phones and 29 million residential extension phones in use on 1 January 1967.[2] These numbers only partly reflect the true capability of a telephone warning system. In terms of telephone availability, the number of households "covered" was 46 million in 1965.[3] This number probably increased somewhat in the following years, undoubtedly at a greater rate than did the total population. Even so, this rather conservative estimate yields a coverage factor of 80.5 percent of the total households in the U.S.

One of the most striking advantages of using a telephone warning system for the residential population is the willingness of people to answer the phone. Years of use and training have sensitized most of the public to the telephone so that

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[1]Wang, et al. op. cit., pp. 29-39, and W. A. Hamberg, A. M. Sales and R. H. Watkins, Study of Tactical Movement Concepts and Procedures for Civil Defense Planning, Operations Research, Inc., Technical Report 210, August 1963, pp. 147-160.

[2]Telephone Engineer and Management Directory, Brookhill Co., Wheaton, Ill., June 1968, p. 13.

[3]Having a telephone available means that an instrument is accessible to members of the household. Generally this would be within the dwelling area, but sometimes the phone would be outside, as in the common hall of an apartment building. See Current Population Reports, op. cit., pp. 2-6.

answering its ring is almost a reflex action.[1] Further, this is a feature not limited to only one segment of the population--the most frequent arrangement in a family is for "the one nearest" to answer the phone. This means that all members of the household are possible recipients of the warning--a disadvantage only if a very young child were to be the recipient.

Business Telephone Warning

In some ways the prospect of using telephone systems for business warning is quite encouraging. The coverage offered by the telephone system is far better than any other medium during normal business hours. For example, there were only 3.5 million business-reporting units listed under the Social Security Act in 1967,[2] but there were over 17 million main plus 10 million extension business phones to service them.[3] Considering the ratio between businesses and phone lines, and taking into account one's own experiences with business, it seems reasonable to assume that telephone coverage is very near complete.

While warning businesses by a telephone system is attractive from the perspective of coverage, it is somewhat less efficient when the speed of dissemination is considered. In the special case of business, speed of dissemination for telephone warning will not be nearly instantaneous. Part of the delay in disseminating warning to businesses is caused by the inability of central offices to ring PBX extension phones. At present, since the call is made to the main number (and alternate

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[1] A recent study of "telephone coincidental" audience survey techniques suggests that certain people have overcome this reflex and do not answer their telephones (although they could have) at some times. The published article was somewhat ambiguous but it appears that about 1 percent of the total sample fell into this category. See, "Flaws Seen in Ratings by Telephone," *Broadcasting*, October 20, 1969, pp. 76-77.

[2] *Statistical Abstract of the United States, 1969*, Table 688, p. 474.

[3] *Telephone Engineer and Management Directory*, *op. cit.*, p. 13.

numbers in the case of trunk/rotary systems) from which it must be manually rerouted to the individual numbers, the warning could not reach all the individual extension phones for some time. This situation has led some people to a concern for the number of PBX systems installed in business and governmental offices, and to consideration of the possibilities of making modifications to PBX switchboards to allow them to function as self-contained warning systems or to relay the incoming warning message.

If telephone warning were the only possible form of effective warning, such concerns would be appropriate. However, no evidence exists to suggest that such is the case and these concerns would therefore appear to be misplaced. On the other hand, because it is true that telephone warning is not now very effective for PBX systems, it is appropriate to modify any estimates of telephone warning effectiveness to allow for this fact.

The first thing to consider in revising telephone warning effectiveness estimates is whether or not the warning is disseminated during business hours. This limits our concern to the 8 AM-to-5 PM period, 5 days a week. (Of course, it would be preferable to make allowances for organizations having different hours, but the information is not available.) The second consideration is the size of the organization being warned. In terms of consequences to warning effectiveness, this is probably the single most important variable for which data are available. When the probable operations of most government and private organizations upon the receipt of telephone warning are considered, it can be seen that the process will be largely similar to that of disseminating word of any high salience news event. For example, in a relatively small office or shop where the number of employees is few, the person receiving the warning would probably be able to inform most of the people immediately by word-of-mouth. In most cases such small units do not have PBX switchboards and, where multiple main phones are available, the number warned by the initial telephone message would be increased by the number of lines used. In larger organizations where switchboards are more likely to be found, the operator will be able to connect the warning call to one or more (depending on the number of incoming

lines) locations from which the warning could be redisseminated. Often the switchboard operator will have immediate access to a public address system over which the message can be disseminated, and in many other cases such facilities as are normally used to announce routine or other events (such as buzzers, bells, klaxons, sirens, etc.) may be used to alert employees and customers.

TELEPHONE WARNING EFFECTIVENESS

Despite the availability of telephone system minutae, little is known of the numbers within phone coverage at any particular hour or of the speed at which a telephone warning system could operate. These two items, of course, constitute the system effectiveness measures used in this paper. Since this information is crucial to the purposes of the project, it was again necessary to make certain estimates and assumptions aimed at providing at least a temporary and rough solution to these deficiencies. As each assumption is specific to the situation in which it was made and applied, it is best discussed within that context.

The analysis of system effectiveness is somewhat unusual in this case. The procedure has been to determine coverage estimates separately for residential and nonresidential populations. These were then combined with each other and with the word-of-mouth dissemination rate found in other situations to obtain overall telephone warning effectiveness estimates.

The residential population estimates shown in Table 2-8 are based on the assumption that anyone not at place of work or at school, or in related transit, must be at home, and that everyone has a home. It would have been more satisfying to adjust these data for those not choosing to remain at home while not working or attending school--but there was no way (within time and funding limits) to do so.[1] Following this basic assumption, it was necessary to identify the population categories affecting telephone coverage.

[1]Note that when telephone warning effectiveness is assessed later in the report, an adjustment factor is introduced to minimize the effect of this assumption.

Table 2-8. Estimated At-Home and At-Home-with-Phone Population--in Millions

TIME	TOTAL U.S.	METRO-POLITAN	NON-METRO-POLITAN	METRO WITH PHONES	NON-METRO WITH PHONES
1 AM	192[1]	124	68	105	49
2	192[1]	124	68	105	49
3	192[1]	124	68	105	49
4	192[1]	124	68	105	49
5	161[2]	104	57	88	42
6	129[2]	83	46	70	33
7	95[2]	62	34	52	25
8	62[2]	40	22	34	16
9	59[3]	38	21	32	15
10	59[3]	38	21	32	15
11	59[3]	38	21	32	15
12	59[3]	38	21	32	15
1 PM	59[3]	38	21	32	15
2	59[3]	38	21	32	15
3	59[3]	38	21	32	15
4	81[4]	52	29	44	21
5	103[4]	67	37	56	27
6	125[4]	81	45	68	32
7	147[4]	95	52	80	38
8	170[4]	109	60	93	44
9	192[4]	124	68	105	49
10	192[1]	124	68	105	49
11	192[1]	124	68	105	49
12	192[1]	124	68	105	49

Sources: Statistical Abstract of the U.S. 1968, Tables [illegible]0, 17, and 150.
Current Population Reports, Series P40, No. 146, "Characteristics of Households With Telephones," Table 2, December 27, 1965.

[1]Census population less 2 percent estimated nightworkers.

[2]Census population less 25 percent of combined labor force and school enrollment per hour.

[3]Consists of those keeping house and children under 5 years plus 2 percent of census population estimated nightworkers.

[4]All in footnote 3 above, plus 16.5 percent of combined labor force and school enrollment per hour increase.

Although such factors as regional location, age and sex of household head, and family income were all related to coverage, the metropolitan/nonmetropolitan distinction was believed to be most useful to the subject. That is, while for the United States as a whole, about 81 percent of the households have telephones, only 73 percent of the nonmetropolitan households have them as compared with 85 percent of the metropolitan households.[1] While these differences could be readily used to determine the numbers with or without telephones in each area, the difficulty experienced in this analysis was in finding the number at home each hour.

Determining the nighttime residential population was relatively straightforward. An estimated 2 percent nightworker population was subtracted from the 1966 Census figures for the 9 PM to-4 AM period. Then, using the assumption that <u>all</u> students and workers are at school and work from 8 AM until 3 PM and 5 PM, respectively, a simple population movement model was postulated. This is, that the movement to school and work from home will occur over a 4-hour period and the movement from school or work to home will occur over a 6-hour period--in proportionate numbers each hour. That is, 25 percent of the combined labor force and school enrollment leave home between 5 AM and 6 AM, another 25 percent between 6 AM and 7 AM, etc., but only 16.5 percent return home per hour after 3 PM.

This population movement model provides only a rough approximation of the actual behavior of people. It is intended to be a conservative approximation of the at-home population, accounting for the major movements in population in the time periods at which they occur. The lower rate in the evening hours is intended to take into account some of the recreational and other uses put to this period, for example, going to dinner, family shopping, early movies, etc. In utilizing the model, the appropriate proportion of workers and students was subtracted or

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[1] <u>Current Population Reports</u>, <u>op</u>. <u>cit</u>., p. 6.

added to the at-home population base according to the hour being considered. Nightworkers were included in the daytime population after 9 AM.

After establishing the at-home and not-at-home population for each time period, it was necessary to compute the number in metropolitan areas and the number in nonmetropolitan areas. These values were used to determine the numbers with telephones living in each type of area--according to the proportions of 85 percent in metropolitan and 73 percent in nonmetropolitan areas. The resultant figures in Table 2-8 are the numbers of people either actually at-home or not at work or school; those visiting or out of the home on other business are not accounted for by these figures. In the following discussion a correction factor is described that will minimize these losses to a telephone warning system.

Calculating the not-at-home population that will be available for telephone warning required using the at-home population complements, adjusted for those who were clearly not available. The population complements, of course, are obtained by subtracting the at-home from total U.S. population. However, knowing the number not-at-home is of little use in determining system effectiveness. The relevant factor is the number of those not-at-home who can be reached--directly and indirectly--by telephone, that is, the number who can be warned by the media and by personal contacts. It was clear that very few of the 3 million members of the armed forces would be available during duty hours for telephone warning. Those directly warned by telephone are likely to have been warned already by some military system. Another category not likely to be available for telephone warning would be the 4 million agricultural workers. While they would doubtless be warned eventually, those in the fields or otherwise removed from dwellings or other phone locations will require a longer than usual time to be warned. Since the rate of warning dissemination would be abnormal for both military and agricultural workers, it was felt that they should not be included in the appraisal of the not-at-home warning capability.

Eliminating those obviously unavailable for telephone warning leaves those who <u>will</u> be warned. Since the not-at-home population is composed primarily of school children and the labor force, it seems that very few people can be directly warned by phone and the remainder must rely on some other warning. The most likely recipients of direct telephone warning--that is, those actually answering a ringing phone--would be switchboard operators and those people with direct lines into their businesses.[1] As there is no reason to believe otherwise (or at least no evidence to the contrary), it was assumed that there would be one person to answer each of the 14 million[2] business phones between the hours of 8 AM and 5 PM. Note that the designation of "business" as used by the phone companies is an administrative/technical term and includes schools and other places requesting such a line as well as commercial and business establishments.

Having settled, albeit expediently, the question of the not-at-home population available for direct warning, it is necessary to determine the approximate speed with which a warning could be disseminated to the remainder of that population group. For the purposes of this discussion it was assumed that all of those not at home would be accessible to those directly warned by telephone.[3] This would include school children who could be alerted by bells or buzzers, then warned by public address systems or told of the danger by teachers as information was passed by word-of-mouth. A similar condition would probably obtain in factories and offices with such noisemakers as buzzers, klaxons, whistles, etc., being used to alert, and word-of-mouth being used to warn of the specific situation. Commercial establishments would probably depend more on word-of-mouth warning, although public address systems are common enough in many of the larger retail stores and firms requiring a great deal of space (lumberyards, car lots, etc.).

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[1] People answering coin phones might also be included but there is no way to estimate their number short of outright guessing.

[2] FCC, <u>Statistics of Communications Common Carriers, 1968</u>, Washington, D.C., 1968.

[3] Note that agricultural and military populations are already removed from these numbers.

Thus the most common type of warning for those who are not at home and who will not be directly contacted by phone warning will probably be a mixture of noise-making devices and word-of-mouth. Since there was no way of knowing who would be alerted first, and because it would provide a fair estimate, it was decided that the warning dissemination rates for "word-of-mouth" would be the best estimates of the warning spread following activation of a telephone warning system.

Table 2-9 presents the estimates of those available for such indirect warning. The "Nonresidential Population" is the total of those who are not at home and therefore not likely to answer a warning telephone call. The speed with which these numbers would be informed of a warning is the same as found by Spitzer and Spitzer[1] in their detailed analysis of the personal sources for news of the Kennedy assassination according to the location of the recipients at the time. The Spitzers found that 67 percent of those at work learned of the shooting within the first half hour. They also found that a total of 67 percent of those at work learned the news from a personal contact, that is, by word-of-mouth. Since the authors were unable to provide data on the first 5-minute and 15-minute intervals, it was necessary to extrapolate values for those intervals. Thus, where Spitzer and Spitzer found 67 percent of those at work aware of the event in 30 minutes or less, we estimated that 25 percent would know in 5 minutes, and 45 percent in 15 minutes. These values were intended to parallel those found by Greenberg[2] of 26 percent in 5 minutes, 40 percent in 15 minutes, and 63 percent in 30 minutes for all sources in his sample.

The products of these computations are hour-by-hour estimates of the number of people who would be indirectly warned by a telephone warning system. To some extent these estimates are the equivalents of the numbers reached by personal

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[1] S. P. Spitzer and N. S. Spitzer, "Diffusion of News of Kennedy and Oswald Deaths," in Greenberg and Parker, op. cit., pp. 105-107.

[2] B. S. Greenberg, "Diffusion in News About the Kennedy Assassination," Ibid., pp. 90-95.

contacts in the EBS or CHAT-TV analyses. Of course the proportions reached in each time interval are quite different, inasmuch as the Table 2-9 data are based only on personal contacts at work and the EBS/CHAT-TV data were based on all personal contacts regardless of location at the time of warning. Then too, telephone warning rates are excluded from this analysis, since the phone system would be dedicated to the primary task of warning or other urgent business during a disaster.

At this writing there does not appear to be any valid means of determining the coverage of speed of dissemination for the at-home-without-phone population. While having this information would be useful in estimating the effectiveness of telephone warning, we have already compiled enough data to make our estimates reasonably credible. To make the estimates themselves, we are required to posit the following:

1. Those with telephones will answer the ring within the first 5 minutes, if they are physically present and able to do so.

2. Those warned at home by phone will be able to communicate the warning to all other household members also at home within 5 minutes.

Neither assumption seems unduly arbitrary: both are used only to simplify warning effectiveness computations. The first assumption is largely intuitive and is followed by most audience survey and market research firms. From a warning standpoint it makes only a minor difference whether it is completely true: those actually at home but not answering the phone during a warning situation will have to be warned by some other source. The utility of this assumption stems from an often overlooked aspect of one of the few empirical telephone warning effectiveness studies ever done. Theodore Wang and others[1] at the Operations Research Office (ORO) of Johns Hopkins University made

[1] Wang, et al., op. cit., pp. 29-33.

Table 2-9. Non-Residential Population* Available for Word-of-Mouth Warning From Telephone Source--in Millions

TIME	NON-RESIDENTIAL POPULATION*	WORD-OF-MOUTH WARNING COVERAGE - NONRESIDENTIAL		
		0-5 MINUTES	0-15 MINUTES	0-30 MINUTES
1 AM	4[1]	1	2	3
2	4[1]	1	2	3
3	4[1]	1	2	3
4	28[1]	1	2	3
5	55[2]	7	12	18
6	83[2]	14	25	37
7	110[2]	21	37	55
8	106[2]	28	50	74
9	106[3]	27	48	72
10	106[3]	27	48	72
11	106[3]	27	48	72
12	106[3]	27	48	72
1 PM	106[3]	27	48	72
2	106[3]	27	48	72
3	106[3]	27	48	72
4	88[4]	22	40	59
5	70[4]	17	31	47
6	51[4]	13	23	34
7	33[4]	8	15	22
8	15[4]	4	7	10
9	4[1]	1	2	3
10	4[1]	1	2	3
11	4[1]	1	2	3
12	4[1]	1	2	3

*Consists of school enrollment and employed persons not in military or agricultural fields or expected to answer telephones for direct warning. Night employment is assumed to be 4 million.

[1] Night employment.

[2] Incremental 25 percent of employed and school enrollment per hour less night workers.

[3] Employed plus school children.

[4] Decrementing footnote 3 by one-sixth per hour.

arrangements to phone employees of the organization after they had completed a questionnaire describing the location of the telephone relative to the sleeping areas. Altogether some 230 phone calls were made between 2 AM and 4 AM. Only 211 were awakened and answered the call; only 5 of the nonanswering group were not at home (these were not identified by Wang as unmarried nightworkers, so we assume the family was away); and the remainder did not respond--presumably because they did not hear the ring. Combined, these "no answers" total 8.4 percent of the sample. Considering that we are interested in obtaining somewhat conservative estimates, and since Wang's group was prealerted to the situation, a loss of 10 percent would seem reasonable to compensate for absentees or those unable to hear the bell. The 10-percent correction factor is only applicable to the at-home population, but it applies for the full 24-hour period. It's obvious that many people leave their homes at all hours for purposes other than to go to work or school. Also, the "at-home" people are not always within earshot of the telephone. For example, being outdoors or near some noisy device such as a washing machine will frequently make hearing the telephone virtually impossible.

The second assumption will not directly affect the final estimates. By assuming that all members of a household will be informed of a telephone warning in 5 minutes or less, we merely affirm the obvious and simplify the computations. Without this assumption it would be necessary to compute intrahousehold warning rates using the closest comparable dissemination speeds. Obviously such a procedure would have been neither practical nor productive. The final procedures used to compute the telephone warning system effectiveness figures shown in Table 2-10 are as follows: First, the at-home-population-with-phone was lowered by 10 percent to allow for failures in answering. These adjusted figures were combined with the 14 million business line answers between the hours of 8 AM and 5 PM. These values were entered in Table 2-10 as the numbers available for being directly warned by telephone warning systems.[1]

[1] As noted, this is not strictly true for at-home household members who do not actually pick up the telephone: they could be counted in the indirectly warned population, but for no practical purpose.

Table 2-10. Telephone Warning Capability--in Millions

TIME	DIRECT CONTACTS BUSINESS AND RESIDENCE*	COMBINED DIRECT AND WORD-OF-MOUTH** 0-5 Min	0-15 Min	0-30 Min
1 AM	139	140	141	142
2	138	140	141	142
3	139	140	141	142
4	139	140	141	142
5	117	124	129	135
6	93	107	118	130
7	70	91	108	126
8	59	86	108	132
9	56	83	104	128
10	56	83	104	128
11	56	83	104	128
12	56	83	104	128
1 PM	56	83	104	128
2	56	83	104	128
3	56	83	104	128
4	72	94	112	131
5	89	106	120	136
6	90	103	113	124
7	106	114	121	128
8	123	127	130	133
9	139	140	141	142
10	139	140	141	142
11	139	140	141	142
12	139	140	141	142

*These data include one person for each main business line, plus the "At-Home" population adjusted for 10% At-Home but not answering phone.

**The word-of-mouch rates are from Table 2-9 and are comprised of the employed non-agricultural/non military and school children.

To determine the warning effectiveness of the telephone warning system at 5-, 15-, and 30-minute intervals, it was necessary only to add the numbers directly to those warned by personal contacts for each period--that is, the not-at-home population; word-of-mouth warning data in Table 2-9 were added to the direct-warning recipients.

The entire procedure is best understood by showing how one hourly estimate was produced. As has been customary in these examples, 12 noon can be used as the demonstration hour. At this time there were an estimated 59 million people at home, of which, 47 million would have telephones in their homes (32 million of the metropolitan and 15 million of the nonmetropolitan population). Ten percent of that total (5 million) was subtracted to compensate for those not answering their phones for reasons other than being at work or school. To the resulting 42 million people warned at home, we added the 14 million people who will answer business phones in a warning situation. The total, 56 million, is the number that can be directly warned by a telephone warning system. The number warned between zero and 5 minutes (83 million) is the sum of those warned directly (56 million) and the nonresidential population warned by personal contacts within 5 minutes (27 million). Similarly, the number warned at 15 minutes (104 million) and 30 minutes (128 million) is the number warned directly (56 million) plus those warned by personal contacts at 15 (48 million) and 30 (72 million) minutes, respectively.

PART THREE: OPTIMIZING WARNING SYSTEM MIXTURES

INTRODUCTION

At the beginning of this project it was our intention to approach the task of identifying an optimum mixture of warning systems from several aspects: speed of dissemination and coverage were to serve as the effectiveness criteria;[1] and cost, reliability, survivability, and warning quality were to be compared to system requirements as supplementary criteria. Once the decision was made to evaluate only the warning systems that actually provided some coverage to the population at a known or predictable rate of dissemination, the systems themselves made further consideration of these supplementary criteria all but pointless.

EBS and CHAT-TV are "free" and their reliability and survivability will vary with the status of the public's receivers and the type of attack postulated. Under the definition of system effectiveness used in this report, other qualities usually associated with effectiveness must be treated apart from the system *per se*. If the messages are convincing and their delivery effective, the public will be convinced and will take the appropriate actions; if the warning message is not credible or convincing, the *systems* cannot be faulted. Telephone warning, however, exists only as a possible technique. Part of the decision to create such a system will entail the absolute and relative costs (as yet unannounced), and the trade-offs between these costs and system reliability and survivability. Outdoor warning systems have been shown to be largely nonsystems, consisting as they do of OCD-funded sirens, mobile sirens, and industrial noisemakers. Applying these criteria to such a collection of facilities is neither appropriate nor feasible.

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[1]These criteria were specified in the scope of work as being the measures of system effectiveness. Other factors (as message credibility) are recognized as being instrumental in the actual effect of a warning system.

Thus final analysis is based on the effectiveness measures for each system and a feeling for some of the practical aspects of system operation and human behavior. The two serve as the analytical categories for determination of an optimum mixture of warning systems. Specifically, the procedures used in this document for selecting an optimum mix are themselves a mix of objective and subjective measures of warning utility.

OBJECTIVE MEASURES

The measures of warning effectiveness for each system essentially provide two things: a measure of the number of people warned in 5-, 15-, and 30-minute intervals, and those same data as they change around the clock. When considered in relation to the standards of warning effectiveness described in Part One, these two aspects of system performance can be used in several ways that should lead to a better appreciation of the whole warning process. First, by comparing the range of warning coverages provided, one begins to have a feeling for the magnitude and direction of differences between what is essentially no warning at all and the particular system. Second, by calculating measures of central tendency for the standards and the specific systems, one can perceive the nature of regularly occurring differences between the two warning approaches. Third, by making frequency counts of the direction of difference for each hourly effectiveness measure, one can begin to assess the consistency of the differences. However, the use of quantitative measures is no assurance of correct interpretation which is indicated in the following paragraphs.

SUBJECTIVE METHODS

It is important to note that even the most sophisticated products of science and technology must be implemented and used by people. This fact demands that we take into account a need for practicality and the presence of vagary when assessing system performance. The best way to accomplish this is to establish and maintain an awareness of two principles: that the best methodology is useless if it is unresponsive to the differences between regularity and importance, and that the performance of a system with humans in it will ultimately depend on unmeasured human values.

A point-by-point analysis of all the practical implications and human values likely to infringe on an optimum mixture of warning system facilities, systems, or techniques is far beyond the scope of this project. All that can be accomplished in this paper is to ensure that these factors are not ignored in light of the "hard" data and methodologies. Some of this intrusion is implicit, such as when we do not permit any sweeping conclusions to be drawn from the findings for any one system; some is explicit, as when the value of a familiar signal for establishing public belief or providing confirmation is introduced as a positive feature of outdoor warning systems.

OPTIMUM MIX ANALYSIS

The following analysis is conducted in two parts. First, each system is compared individually to the warning effectiveness standards derived from the spread of high saliency news (abbreviated in parts of the comparison tables as H-S News). These individual comparisons are intended to supplement the discussion provided in Part Two by fitting the system into a rather special perspective, where the system is evaluated for its ability to reach the public at any hour of the day within specified intervals, in contrast to the ability of normal news dissemination channels to accomplish the same tasks.

The second part of the analysis is directed to comparing the differences between all the systems and the warning standards. These comparisons and evaluations are used in the final determination of a mixture of systems that will provide the most favorable warning capability on a 24-hour basis.

WARNING STANDARDS AND SYSTEMS

The following paragraphs describe the comparisons between each warning system and the warning standards.

Outdoor Warning and Standards of Effectiveness

In the particular case of comparing the effectiveness of outdoor warning systems to that of the standards, it was necessary to adjust these data to the same

population base--the outdoor estimates being for metropolitan areas, the warning standard being based on total U.S. population. Since the greater distortion would be to extrapolate the metropolitan data to the U.S., all population data in Table 3-1 are adjusted to proportions for metropolitan areas.

The data in Table 3-1 are arranged to provide ready comparisons of system effectiveness between the two at 5-, 15-, and 30-minute intervals for each hour of the day. The difference in coverage for each period and interval is adjacent to each population coverage value. When the difference in effectiveness yields a negative coverage value it means that the warning "system" would reach that many fewer people within the interval than would the normal news channels. In general, the outdoor warning capability appears to run a little behind or barely even with the warning standards. A closer inspection of the data shows that in the 5-minute interval the warning standards perform almost twice as well as the outdoor system, having a low of 20 million warned and a high of 49 million compared to a low of under one million and a high of 23 million for the outdoor system. Within the 15-minute interval the two are almost even, with a slight edge going to the outdoor system: 34 low and 73 million high compared to 28 low and 67 million high for the warning standards. At the 30-minute interval the advantage has shifted back to the standards, with a low of 55 and a high of 85 million for the outdoor system. These figures seem clear enough. The general impression of the warning standards having a slightly greater warning capacity is confirmed for two of the three intervals.

When the average number warned per hour is calculated, the same basic relationship is maintained only the differences are magnified. For each interval, the warning standard average hourly coverage was 32 million, 44 million and 74 million. The outdoor system hourly average coverage was 11 million, 54 million and 71 million. When the average difference is computed as the percentage of the warning standards coverage, it appears that the outdoor system suffered an average hourly loss of 65 percent in the 5-minute interval, an average gain of 23 percent within 15 minutes, and a loss of 4 percent at the 30-minute interval.

Table 3-1. Metropolitan Area Outdoor Alerting Capability Compared with Metropolitan High Saliency News Dissemination--in Millions Reached

TIME	5-MINUTE H-S NEWS DISSEMI-NATION	5-MINUTE OUTDOOR ALERTING CAPABILITY	DIFFERENCE	15-MINUTE H-S NEWS DISSEMI-NATION	15-MINUTE OUTDOOR ALERTING CAPABILITY	DIFFERENCE	30-MINUTE H-S NEWS DISSEMI-NATION	30-MINUTE OUTDOOR ALERTING CAPABILITY	DIFFERENCE
1 AM	23	-	-23	31	46	15	59	62	3
2	21	-	-21	28	42	14	55	60	5
3	20	-	-20	26	38	12	54	55	1
4	20	-	-20	26	34	8	54	55	1
5	20	-	-20	26	42	16	54	59	5
6	23	-	-23	31	42	11	61	59	-2
7	27	1	-26	37	46	9	68	64	-4
8	29	8	-21	39	49	10	73	69	-4
9	31	13	-18	43	59	16	75	75	0
10	32	15	-17	44	57	13	75	74	-1
11	32	20	-12	45	61	16	77	76	-1
12	32	25	- 7	39	73	34	77	85	8
1 PM	33	23	-10	46	71	25	79	84	5
2	33	22	-11	47	68	21	72	81	9
3	34	20	-14	48	65	17	77	80	3
4	35	18	-17	50	64	14	80	81	1
5	35	16	-19	50	61	11	80	79	-1
6	39	16	-23	56	57	1	86	77	-9
7	41	16	-25	61	56	-5	90	76	-14
8	43	16	-27	65	60	-5	95	77	-18
9	49	16	-33	67	60	-7	95	77	-18
10	42	12	-30	64	56	-8	92	72	-20
11	37	8	-29	54	51	-3	79	68	-11
12	28	4	-24	40	48	-8	68	66	-2

These figures, too, merely confirm the obvious, although with more specificity and greater precision.

It is the inspection of the hourly differences that provides the most interesting observations. Outdoor warning performs worst when the normal news channels perform best. This would not be surprising if the systems were in competition so that one would take from the other. However, this is not directly the case. The explanation lies in the fact that the mass media make a large contribution to warning standards effectiveness, but while people are indoors, subjected to the higher noise levels of the home, they are less able to hear the outdoor devices. The outdoor system performs best between 11 AM and 4 or 5 PM depending on the interval. These are the periods during which there are more people outdoors and a lower ambient noise level. These hours are not low points for the warning standards. This indicates that while outdoor warning may not be very effective when compared to other systems, it is probably reaching a part of the population while they are not readily available to other sources. However, since these effectiveness figures include word-of-mouth sources, it would be ill advised to assume that many of those outdoors are very inaccessible; most likely outdoor warning would merely reach them sooner--as within the 15-minute interval, where that system shows at its best.

Crisis EBS Warning and Standards of Effectiveness

A first look at the data suggests that Table 3-2 will provide few surprises, and rightly so. The warning standards are very close to EBS in a surprise attack situation, so the differences shown are much like those that would occur to EBS as a result of a well-publicized crisis. The changes *should* be increases over the warning standards.

When the ranges for each interval are examined, the consistencies become more clear. The respective warning standards are a low of 31 and a high of 68 million. At 5 minutes EBS has a low of 35 and a high of 74 million warned--a small but distinct improvement at both ends of the spectrum. Similarly, at 15

Table 3-2. Warning Dissemination Capability of EBS during Crisis Compared with High Saliency News Dissemination--in Millions Reached

TIME	5-MINUTE H-S NEWS DISSEMI-NATION	5-MINUTE EBS CAPABILITY	DIFFERENCE	15-MINUTE H-S NEWS DISSEMI-NATION	15-MINUTE EBS CAPABILITY	DIFFERENCE	30-MINUTE H-S NEWS DISSEMI-NATION	30-MINUTE EBS CAPABILITY	DIFFERENCE
1 AM	35	62	27	48	93	45	91	136	45
2	33	47	14	44	68	24	86	112	26
3	31	38	7	41	52	11	84	95	11
4	31	35	4	41	47	6	84	90	14
5	31	35	4	41	47	6	84	90	14
6	36	40	4	48	54	6	94	101	7
7	42	44	2	57	61	4	105	109	4
8	45	48	3	61	68	7	113	121	7
9	48	54	6	67	77	10	116	127	11
10	49	56	7	68	81	13	116	129	13
11	50	58	8	70	85	15	119	133	14
12	50	61	11	61	88	27	119	136	17
1 PM	51	61	10	72	85	13	122	138	16
2	51	62	11	73	93	20	111	140	29
3	52	64	12	75	96	21	120	142	22
4	54	66	12	77	98	21	124	145	21
5	54	69	15	78	102	24	124	148	24
6	60	71	11	87	102	15	134	153	19
7	63	74	11	94	113	19	139	159	20
8	67	74	7	101	113	12	148	157	9
9	68	73	5	104	112	8	148	156	8
10	65	73	8	99	112	13	143	156	13
11	57	74	17	84	110	22	123	157	34
12	43	65	22	62	97	35	126	140	14

minutes the warning standards are 41 low and 104 million high, while EBS has a low of 47 and a high of 113 million--about the same kind of increase. The improvement is only slightly more pronounced at 30 minutes when the warning standards are 84 and 148 million, low and high respectively, and EBS reaches 90 low and 159 million high while here the major change is at the high end: 11 million more people warned at the peak period is a substantial improvement.

The hourly averages also support the idea of consistent improvement for "crisis" EBS. For each interval EBS has an hourly average of 59, 86 and 132 million coverage. The warning standards are 49, 69, and 116 million, respectively. Converted in percentages of the warning standard values, the EBS increases are 20 percent per hour at 5 minutes, 24 percent per hour at 15 minutes, and 14 percent per hour at 30 minutes.

Inspection of the hourly variations yields only one anomaly; crisis EBS makes its smallest gain and achieves its lowest coverage during the late night, early morning hours. While this is in no way surprising, it provides additional support for the CHAT-TV concept discussed next.

EBS/CHAT-TV Warning and Standards of Effectiveness

An overview of Table 3-3 quickly reveals that the inclusion of CHAT-TV to the EBS (during a crisis) produces major improvements to the weakest EBS periods and to the overall warning capability of the system. In considering the range of warning coverage we see that dramatic improvements have been made to the low side for each interval. At 5 minutes EBS/CHAT-TV has a warning capability of 48 and 74 million, in contrast to the unchanged warning standards low of 31, high of 68 million. The improvement in the low end of the range at 15 minutes is also quite impressive: EBS/CHAT-TV has a low of 69 and a high of 113 million, compared to the warning standards of 41 and 104 million. The low end increase for the 30-minute interval is still substantial: 111 million is the EBS/CHAT-TV low compared to 84 million as the warning standards low. Their respective high ends remain as for EBS without CHAT-TV.

Table 3-3. Warning Dissemination Capability of EBS/CHAT-TV during Crisis Compared with High Saliency News Dissemination--in Millions Reached

TIME	5-MINUTE H-S NEWS DISSEMI-NATION	5-MINUTE EBS/CHAT TV CAPABILITY	DIFFERENCE	15-MINUTE H-S NEWS DISSEMI-NATION	15-MINUTE EBS/CHAT TV CAPABILITY	DIFFERENCE	30-MINUTE H-S NEWS DISSEMI-NATION	30-MINUTE EBS/CHAT TV CAPABILITY	DIFFERENCE
1 AM	35	67	32	48	102	54	91	145	[illegible]
2	33	63	30	44	95	51	86	137	51
3	31	59	28	41	88	47	84	130	[illegible]
4	31	57	26	41	86	45	84	129	45
5	31	57	26	41	86	45	84	129	45
6	36	56	20	48	85	43	94	122	28
7	42	48	6	57	69	12	105	111	6
8	45	53	8	61	75	14	113	123	10
9	48	55	7	67	79	12	116	133	17
10	49	56	7	68	81	13	116	129	13
11	50	58	8	70	85	15	119	133	14
12	50	61	11	61	88	27	119	136	17
1 PM	51	61	10	72	85	13	122	138	16
2	51	62	11	73	93	20	111	140	29
3	52	64	12	75	96	21	120	142	22
4	54	66	12	77	98	21	124	145	[illegible]
5	54	69	15	78	102	24	124	148	24
6	60	71	11	87	102	15	134	153	19
7	63	74	11	94	113	19	139	159	20
8	67	74	7	101	113	12	148	157	12
9	68	73	5	104	112	8	148	156	8
10	65	73	8	99	112	13	143	156	13
11	57	73	16	84	111	27	123	155	32
12	43	69	26	62	105	43	126	149	23

When the average hourly coverage is compared, these differences take on added importance. The EBS/CHAT-TV hourly averages for each interval are 66 million, 94 million, and 140 million; corresponding values for the warning standards are 49 million, 69 million, and 116 million. These increases in coverage capability were computed from the warning standards as the base. At 5 minutes the average hourly increase over the standards is 30 percent. For the 15-minute interval the average EBS/CHAT-TV produced increase is 37 percent. The increase at 30 minutes is 21 percent.

The trend for an overall improvement to warning effectiveness when CHAT-TV is added to EBS is further supported when the individual hourly data are examined. As might be expected, the greatest increases are where EBS alone is least effective--the late night, early morning hours. Some low improvement periods still remain, caused for the most part by low television use patterns during peak travel hours without an equivalent increase in radio audiences. The effect of this behavior, particularly in the morning, is quite pronounced. Of course, it should be remembered that the "time zone audience loss" is working on CHAT-TV during the morning hours, i.e., as the EST zone audience is awakened by CHAT-TV at 7 AM, they go about their business preparing for work and school, etc., and listen much more to the radio than to any other mass medium; before the next surge in the television audience is expected, CHAT-TV users in the Central, Mountain and Pacific time zones will have made similar transitions. While the net effect appears large in comparison to previous hourly coverage gains, the fact is that the actual coverage during these times is still quite substantial.

Telephone Warning and Standards of Effectiveness

Even the most cursory perusal of the data in Table 3-4 reveals that major improvements in warning effectiveness can be obtained using a telephone warning system. The increases, however, appear most impressive in the 5- and 15-minute intervals, with a drop in the rate of increase occurring in the 15- and 30-minute intervals.

Table 3-4. Telephone Warning Capability in Comparison with High Saliency News Dissemination--in Millions Reached

TIME	5-MINUTE H-S NEWS DISSEMI-NATION	5-MINUTE TELEPHONE CAPABILITY	DIFFERENCE*	15-MINUTE H-S NEWS DISSEMI-NATION	15-MINUTE TELEPHONE CAPABILITY	DIFFERENCE*	30-MINUTE H-S NEWS DISSEMI-NATION	30-MINUTE TELEPHONE CAPABILITY	DIFFERENCE*
1 AM	35	140	105	48	141	93	91	142	51
2	33	140	107	44	141	97	86	142	56
3	31	140	109	41	141	100	84	142	58
4	31	140	109	41	141	100	84	142	58
5	31	124	93	41	129	88	84	135	51
6	36	107	71	48	118	70	94	130	36
7	42	91	49	57	108	51	105	126	21
8	45	86	41	61	108	47	113	132	19
9	48	83	35	67	104	37	116	128	12
10	49	83	34	68	104	36	116	128	12
11	50	83	33	76	104	28	119	128	9
12	50	83	33	61	104	43	119	128	9
1 PM	51	83	32	72	104	32	122	128	6
2	51	83	32	73	104	31	111	128	17
3	52	83	31	75	104	29	120	128	8
4	54	94	40	77	112	35	124	131	7
5	54	106	52	78	120	42	124	136	12
6	60	103	43	87	113	26	134	124	10
7	63	114	51	94	121	27	139	128	11
8	67	127	60	101	130	29	148	133	15
9	68	140	72	104	141	37	148	142	6
10	65	140	75	99	141	42	143	142	1
11	57	140	83	84	141	57	123	142	19
12	43	140	97	62	141	79	126	142	16

*Excludes those learning of H-S News by telephone or face-to-face contacts.

This observation is confirmed when the ranges of warning coverage are considered, although the size of the low ends of telephone coverage continue to be impressive in all intervals. In the first 5 minutes the lowest value for telephone warning is 83 million, its highest value 140 million. The range for the warning standards is, as before, a low of 31 million and a high of 68 million. For the 15-minute interval the difference between the high values has shortened somewhat because of the telephone system having gained only one million more while the warning standards high coverage value is 104 million. At the low end of the range the telephone system has continued to make impressive gains: its lowest value in the interval is the same as the highest warning standards value, 104 million. This compares most favorably with a low of 41 million for the warning standards. At 30 minutes the upper limits for both systems show a reversal of position for the two systems, although the difference is small: 148 million warned by the warning standards compared to 142 million by telephone. However, the low end of the range once more shows the superiority of the telephone system--with 124 million being the low value in contrast to the 84 million low value for the warning standards.

Examining the average hourly coverage reveals some additional dimensions of the warning picture. Telephone warning achieves a nearly instantaneous average coverage of 111 million in the first 5 minutes. Compared to the average for the warning standards base of 49 million, this represents a 128 percent increase in effectiveness. Telephone warning coverage averages 121 million by 15 minutes, a 76 percent increase over the base of 69 million covered by the warning standards. At 30 minutes telephone warning coverage averages 134 million, an 18 percent increase over the warning standard 116 million coverage.

Reviewing the individual effectiveness values produces very little more in the way of interpretive material. The system obviously works best in the 8 PM to 5 AM period. Of course this taps the population at a time when more people are likely to be at home. Then too, it is not necessary to consider the inability of the telephone to awaken sleepers, as research findings indicate it is remarkably effective at that task.

It may also be of value to point out the varying improvement to telephone warning resulting from the inclusion of personal contact sources at each hour. While these sources exert very little effect in the periods of peak telephone capability (8 PM to 5 AM), the increases in coverage within 15 and 30 minutes during the 6 AM to 7 PM hours are a direct result of word-of-mouth sources extending telephone coverage. The consequence of all this activity is that the coverage at 30 minutes is remarkably high and tightly clustered in the 130-140 million area. Of course, this merely amplifies the observation--first stated in the discussion of coverage ranges--that telephone warning provides a maximum of coverage and a minimum of dispersion.

OPTIMUM WARNING MIXTURE

The foregoing discussion was intended to provide a better understanding of the effectiveness of each system relative to the warning standards. The present section takes this understanding one more step by comparing the system comparisons to reach a determination of the optimum mixture of systems. For the purposes of this paper, an operational definition will be used to specify the limits of the optimum mixture. Specifically, an optimum mixture of warning equipments, systems, and techniques is one that:

a. Provides the maximum warning coverage in the minimum interval of time.

b. Provides the greatest effectiveness capability over the 24-hour day.

c. Allows for flexible allocation of resources and funds in the process of system development and operation.

d. Considers relevant human factors in the final configuration.

The determination of an optimum mixture is made by using the comparative measures of warning standards and systems as the "raw data" of the analysis.

These data are treated to various ordering and summarizing techniques aimed at identifying specific system relationships, i.e., relative coverage per time interval and per day, proportional warning improvement per time interval and for total, etc. These findings are analyzed and interpreted in light of practical and human aspects of warning system operation and conclusions are drawn relating to the optimum mix. Some recommendations for future research are also made.

Comparative Ranges of Coverage

When the ranges of coverage in each time interval for all the warning standards and systems are arrayed in one place, it quickly becomes obvious that no one system gives best, or worst, coverage. The evaluation is complicated by the presence of two different environments (metropolitan and total U.S.), three time intervals (5, 15, and 30 minutes) and an upper and lower coverage value to each range.

Since the population base is different for the outdoor warning system, there was no meaningful way to compare its coverage range with those of the other systems. However, EBS, EBS/CHAT-TV, and telephone warning systems could all be compared to the warning standards and to each other, and the outdoor system can be compared to the metropolitan warning standards. The comparative method used is to rank each system according to its population coverage on the high and low ends of the range during each time interval. The ordering scheme used is to assign first place to the highest coverage system, second place to the next highest coverage, etc. In case of a tie, the ranks are totaled and divided by the number of tying systems. Each system then receives the average position of the contending systems. To illustrate the process: the range of coverage values for the 5-minute interval are Standards, 31-68 million; EBS, 35-74 million; EBS/CHAT-TV, 48-74 million; and telephone, 83-140 million. The rank order of these systems at the low end of the ranges is: 1--telephone; 2--EBS/CHAT-TV; 3--EBS; and 4--warning standards. At the high end of the range the rank order is: 1--telephone; 2.5--EBS (tie); 2.5--EBS/CHAT-TV (tie); and 4--warning standards.

Table 3-5 presents the full array of the system ranks and the average rank of each system for all the ranks. The ordering of ranks for each class was accomplished as described above. The averages for each system were obtained from the total for each system row.

Table 3-5. System Ranks for Coverage Ranges within Time Intervals and for Totals

SYSTEM	0-5 MINUTES LOW	0-5 MINUTES HIGH	0-15 MINUTES LOW	0-15 MINUTES HIGH	0-30 MINUTES LOW	0-30 MINUTES HIGH	AVERAGE RANK
Warning Standards	4	4	4	4	4	3	3.8
EBS	3	2.5	3	2.5	3	1.5	2.6
EBS/CHAT-TV	2	2.5	2	2.5	2	1.5	2.1
Telephone	1	1	1	1	1	4	1.5
Metropolitan Warning Standards	1	1	2	2	2	1	1.5
Outdoor	2	2	1	1	1	2	1.5

When considering these data certain regularities become quite clear. First, for the total U.S. systems, the rank order at the low end of the range is consistent for all intervals: 1--telephone; 2--EBS/CHAT-TV; 3--EBS; 4--warning standards. The inference is clear: If a primary goal of the optimum warning mix is to assure the highest coverage at all hours of the day, then the emphasis in system implementation should be in that order of preference. There is no comparable regularity of ordering for optimizing a system according to a need to reach the largest number of people at a particular hour of the day for each interval. The trend is for the telephone system to lead in reaching the most people in the first two intervals and for EBS and CHAT-TV to tie in all three, sharing top coverage in the 30-minute interval. Telephone warning drops to last place at 30 minutes, falling behind even the warning standards in this one instance.

The average ranking for the systems provides a reasonably sensitive indication of each system's relative location in the array of population coverage ranges. The telephone system is the leader, but its overall position is really a compromise between first and second place. EBS/CHAT-TV is in second place but its position is not secure, since EBS is barely half a rank behind. One aspect of this analysis is especially encouraging: clearly all three systems are improvements over the warning standards, which is firmly in last place.

This is not so true of the metropolitan area warning standards, which trades positions with outdoor warning about evenly for all three intervals. Since there is no clear advantage or disadvantage to either warning approach, it is advisable to defer evaluating these facilities until more data are reviewed.

Comparative Hourly Coverage

One other dimension of coverage offers an opportunity for obtaining more useful information on system relationships. This is the hour-by-hour, within-interval, rank order of the warning standards and systems. Use of this approach gives an indication of the within-interval consistency of any system relative to the others.

The method used is to order the standards and systems according to the population coverage for each hour within the 5-, 15-, and 30-minute intervals. The ranks are totaled over the 24 hours for each system during the interval and average ranks for the systems are computed. These are the values in Table 3-6. An example of the procedure will aid in understanding. At 1 AM the 5-minute warning standard coverage value is 31 million. The comparable coverage for EBS is 62 million, for EBS/CHAT-TV the value is 67 million, and for telephone warning the coverage is 140 million. The respective ranks for that time period are: 1--telephone warning; 2--EBS/CHAT-TV; 3--EBS; and 4--warning standards. This ranking procedure was completed for each hour and system in the 5-minute interval, yielding a sum of ranks of 24 for telephone warning, 55.5 (tied ranks) for EBS/CHAT-TV, 64.5 for EBS, and 96 for the warning standards. The hourly averages

Table 3-6. Average System Ranks for Individual Hourly Coverage within Time Intervals

SYSTEM	0-5 MINUTES	0-15 MINUTES	0-30 MINUTES	AVERAGE
Warning Standards	4	4	4	4
EBS	2.7	2.7	2.1	2.5
EBS/CHAT-TV	2.3	2.3	1.6	2.1
Telephone	1	1	2.3	1.4
Metropolitan Warning Standard	1	1.75	1.5	1.4
Outdoor	2	1.25	1.5	1.6

were computed for the interval and the process repeated for the remaining intervals and for the metropolitan area data.

Examination of the data in Table 3-6 shows a pattern similar, but not identical to, the preceding findings. For the overall systems it appears that telephone warning is again consistently superior in the first two intervals and loses ground in the 30-minute interval. Because telephone warning is ranked unequivocably first (a 1.0 order) in both the 5- and 15-minute intervals, it indicates that there was no instance in either interval where telephone warning coverage was exceeded by the other systems or the warning standards. EBS/CHAT-TV split second place with, while maintaining a slight edge over, EBS in both the first two intervals. The warning standards held last place in all intervals and for an average rank.

The top rank in the 30-minute interval was held (barely) by EBS/CHAT-TV. EBS and telephone warning divided second and third places, with the higher relative position going to EBS. The overall averages for the systems reveal that telephone warning holds the top rank, giving an impressively consistent performance

considering that it provided maximum coverage in all but 17 of the 72 measurements used in the rankings.

Second rank is held by EBS/CHAT-TV, followed closely by EBS in the third position. These two systems, of course, share many of the same coverage measures--but not so many that the closeness of the rankings would have been expected. These data suggest that the value added to EBS by CHAT-TV may not be so consistent. However, inspection of the coverage values where the inconsistencies occurred reveals that the EBS advantage is only 1-2 million--easily within the tolerances that should be allowed for these coverage data. Thus, the inconsistencies are probably more apparent than of real import.

Inspection of the metropolitan area data reveals the same indeterminancy in performance found between the warning standards and the outdoor warning system in the previous section. The warning standards are clearly ranked first in the first 5 minutes, then they are second, then they split the 30-minute interval with outdoor warning. The most conclusive finding yet for the metropolitan data lies in the narrow lead held by the warning standards when the average ranks are considered.

Total Warning Improvement

The preceding discussions have treated the systems and warning standards as separate entities, and all computations were made of the individual differences. If assessments of proportional (rather than relative) worth are to be made, it is necessary to identify some "warning totality" to which each system is a contributor. The most desirable condition would be to obtain some absolute measure of warning effectiveness and the particular contributions of the warning systems, personal contacts, and any other dissemination techniques. However, as the system effectiveness measures devised by this study are not additive because there is no way of identifying overlapping warning coverage, we must be satisfied with lesser measures.

The particular warning totality used in this study is no real totality at all--it is a measure constructed from the measured improvements over the warning standards obtained by the individual systems. It is called the Total Warning Improvement Measure (TWIM). The purpose of the TWIM is simply to provide a reasonable basis for making determinations of proportional worth, and therefore a basis for reaching conclusions about the allocation of resources.

TWIM comprises the combined average hourly differences between systems' performance and the warning standards. As observed earlier, when the warning system provides greater coverage than the warning standard, the difference is a quantitative measure of improvement. The average of these hourly improvements gives an indication of the overall worth of the system compared to the warning standards. Combining the improvements for the three systems for which there were improvements, as shown in Table 3-7, illustrates the derivation of TWIM. Each value within the table has been discussed previously in system comparisons sections; the marginal value at the row and column totals, 240 million, is the Total Warning Improvement Measure. Although it is patently impossible to achieve this total improvement (being in excess of the U.S. population) in coverage, the fact is that it does measure overall systems improvement.

Table 3-7. Average Hourly Warning Improvement Measures--in Millions

SYSTEM	5 MINUTES	15 MINUTES	30 MINUTES	TOTALS
EBS	10	17	16	43
EBS/CHAT-TV	15	25	24	64
Telephone	62	53	18	133
Totals	87	95	58	240

This becomes more clear when the numerical improvement values are converted into proportions, as in Table 3-8. As percentages, the improvements to warning effectiveness can be viewed as abstractions rather than as representing millions of people. In this context the figures should not represent concrete realities but "increases" over measured standards of warning effectiveness.

Table 3-8. Average Hourly System Contribution to Total Warning Improvement Measure--in Percent

SYSTEM	5 MINUTES	15 MINUTES	30 MINUTES	TOTAL
EBS	4	7	7	18
EBS/CHAT-TV	6	11	10	27
Telephone	26	22	7	55
Totals	36	40	24	100

The analysis of these data is of particular importance in making decisions regarding the allocations of resources to warning. As can be seen in Table 3-8, there are two dimensions of warning improvement being measured. The data and totals for the rows measure the individual system contribution to warning improvement. The column data and totals show the system contributions to improvements occurring within each time interval. Used together, the findings are very instructive, although not unanticipated in view of the prior analyses.

The most apparent feature of the data is the dominance of the telephone warning as a contributor to the TWIM. Telephone warning contributes the bulk of the improvement in the 5- and 15-minute intervals, and the majority of the improvement overall. Even in the 30-minute interval, telephone warning contributes equally with EBS, and only 3 percent less than EBS/CHAT-TV. EBS/CHAT-TV is second to telephone warning as a contributor to TWIM. Its improvement to warning is greater than that of EBS in all three intervals and greater than that of telephone warning in the 30-minute interval.

From the perspective of making improvements to warning dissemination speed, the greatest amount of improvement is obtained in the first two intervals, with the bulk of the improvement again resulting from telephone warning. However, even when that contribution is ignored, the 5- and 15-minute intervals still provide the majority of the warning improvement. The 24-percent improvement obtained in the 30-minute interval is substantial, but cannot match the individual or combined improvement of the other intervals.

OPTIMUM MIXTURE DETERMINATION

This section consolidates the separate findings of the previous section, assesses these findings, and reaches a determination of an optimum warning mixture. The procedure uses reason to moderate technique, and experience to supplement numerical evidence.

In reviewing the comparative data for the warning systems, several general observations can be made:

1. The system offering the greatest overall potential on all the measured dimensions is telephone warning.
2. Telephone warning gives the most coverage in the least time.
3. Telephone warning provides the most consistent, 24-hour coverage capability.
4. Telephone warning provides the maximum warning improvement.
5. EBS and EBS/CHAT-TV are usually capable of reaching the largest total number of people within 30 minutes.
6. The combination of EBS and CHAT-TV (during a crisis) proved to be second only to telephone warning on all factors tested but one, where it excelled.
7. Except in the case of outdoor warning, the systems considered were all more effective than the standards of warning effectiveness.

8. Outdoor warning proved no more effective than the warning standards in most of the comparisons made in the study, and was less effective in some.

Based on these observations, it is logically necessary to conclude that an effort to develop an optimum warning mixture would assign top priority to establishing a telephone warning system. Second priority would be accorded to CHAT-TV, so that the broadcast industry has a late night warning capability available for use in a crisis. The Emergency Broadcast System would be accorded a priority behind that used to develop and improve CHAT-TV. Outdoor warning would be sustained in the metropolitan areas until a more effective system was implemented.

If desired, the allocation of resources for local warning could be programmed to match the proportional average hourly improvement contributions shown for the systems in Table 3-8. That is, as telephone warning offers the potential of a 55 percent improvement over the warning standards, it would be appropriate to allocate a like amount of the warning resources to improving that system. Similarly, 27 percent of these resources could be allocated to CHAT-TV, and 18 percent to improving the EBS capability. Since outdoor warning makes no contribution to total warning improvement, it would not be necessary to allocate resources for local warning improvement to further develop that system.

Not too surprisingly there are several modifications to this very logical schema of priority and resource allocation. The changes are qualifications to the schema and are not presently amenable to being reduced to a quantified form. In brief, the changes believed necessary are: 1) apportion some resources to developing promising alternative systems currently too undefined to warrant a determination of effectiveness potential or assigning of priorities, and 2) continue maintenance allocations for outdoor warning until a near perfect indoor and outdoor warning system is devised.

These changes are suggested for some very sound--albeit unmeasurable--reasons. For example, telephone warning is effective for the same reasons that several other systems could be, although it has not yet been shown to be as technically feasible as those systems. It would be well, then, for some effort to be directed to developing those system capabilities. However, rather than simply dividing the resources allocated to telephone warning, one or the other of the EBS options should be selected for development and the other scrapped, and those resources combined with the others and reapportioned. The second recommendation was advanced because of the fact that outdoor warning will continue to provide values equal to, or greater than, the "costs" of dismantling the system. These factors are discussed in detail below.

The effectiveness of telephone warning does not stem from any advantage in the number of households it serves. In fact, there are more households with either radio (98.6 percent) or television (96.9 percent)[1] than with telephones (80.5 percent). Neither does it have any advantage over the mass media in being collocated with the population, except perhaps during working hours when business phones are collocated with business people. At other times people are very often near operating mass media devices, e.g., car radios, home radio or television sets, and units operating in stores, bars, etc.

Telephone warning has several features which no existing capability can match, one for one. First, the telephone signal is familar and, to most of us, urgent. Then too, telephone warning is a full period, positive control system. That is, it can be activated 24 hours a day by some specific action on the part of the warning agency. At the time of activation all warning units are operated, not just the ones currently in use. Only CHAT-TV approaches this--for the 8 hours or so it would operate.

The EBS National Industrial Advisory Committee is field testing a tone-activated receiver which, if successful, should be able to produce an urgent signal and would have equal full-coverage and positive-control features.[2] Since any EBS

[1] Broadcasting Yearbook, 1969, op. cit., p. 25.

[2] The test is described in "EBS Gets September Shakedown," Broadcasting, August 11, 1969, p. 48. OCD has financed the development of this NIAC alert receiver.

plan would use standard radio and television receivers, this plan stands (in time) to increase coverage substantially over the telephone warning capability. Comparable benefits would also accrue to Decision Information Distribution System (DIDS) should a decision ever be made to implement a public warning capability. Two extra features would be the 30-second activation time for DIDS--the lowest published response time of any warning system--and the limited number of control transmitters, minimizing the error probability over any civilian system. DIDS is also being field tested.

The fact that there are other systems with a capability equal to or better than telephone warning already being field tested dictates that a great deal of restraint be exercised in urging substantial developmental efforts be directed to telephone warning--particularly until the system proves feasible, practical, etc., or until EBS and DIDS prove unworkable.

Reallocating resources in light of alternative systems is a decision best deferred until the alternative systems have been defined well enough to allow useful effectiveness estimates to be developed. Presently neither of the two systems believed to be capable of equalling or bettering telephone warning effectiveness is known to be under serious consideration for public adoption as well-defined systems. Until more is known about receiver distribution, activation latency, etc., it is pointless to speculate on their potential effectiveness or on their probable contributions to warning improvement.[1]

Assessing the priorities and allocations of resources assigned EBS/CHAT-TV and EBS is made difficult by the fact that both systems' effectiveness measures assume a crisis. In the case of a surprise attack, these measures and all comparisons with the effectiveness standards and other systems would be

[1]Were the telephone, EBS, and DIDS warning systems to prove equal, it would soon eliminate the need for considering further development of CHAT-TV or EBS as presently known. Resources could then be allocated equally to all three systems.

meaningless. The fact that this uncertainty exists is ample justification for recommending that some reallocation of resources would be appropriate. The shift should be made to identifying and developing a system less dependent on a political crisis of public import for successful operation. This reallocation could also be supported on the grounds that while two systems have been described, only one can exist. That is, EBS operates either with or without CHAT-TV: there cannot be two EBS systems at the same time. The obvious implication is that one version should be selected for continued development and the resources allocated for the other version be used for the purpose selected.

Outdoor warning systems have been shown to offer no real improvement to warning effectiveness, even though the coverage values used in the computations were considered optimistic. Had those coverage estimates been limited to the formal, OCD-funded siren system, the results would have been even more discouraging.[1] However little improvement outdoor warning offers, there are several factors militating against taking action aimed at eliminating the function, that is, at least until some spectacular indoor and outdoor warning breakthroughs are made--a fairly remote possibility according to Neilson and Lamoureux.[2]

Outdoor warning does provide some values beyond its "cost" that are not reflected in the basic effectiveness measures. For example, some parts of the system are uniquely adapted to a particular environment, as a noisy factory, where a more generalized system would not be adequate for those conditions. Other parts are mobile (especially the police and fire sirens), giving the "system" a flexible response capability difficult for most general systems to duplicate. Then too, many of the signalling devices are already located in downtown areas where they are likely to be most effective.[3] However, these same parts of the city are

[1]Table A-7 in the Appendix shows the results of using that coverage assumption without adjusting the figures for environmental effects.

[2]Neilson and Lamoureux, Improved Outdoor Alerting and Warning, op. cit., p. 32 and passim.

[3]Ibid., pp. 83-84.

likely to have a lower proportion of households with a telephone than in the suburban fringe, so that telephone warning would be less effective than otherwise expected.[1]

Finally, unless the system replacing outdoor warning was perfectly effective, credible, reliable, survivable, and so forth, the redundancy value alone would justify maintaining the system. As Bosak, et al.,[2] and others have shown, the vast majority of people facing an uncertain threat look to other sources for amplification and confirmation. It is safe to assume that the failure of police and fire vehicles to sound their sirens and use their flashing lights, or of city officials to activate the "air raid" sirens, etc., would introduce a great deal of uncertainty as to the validity of any other warning system. People are familiar with and expect these emergency cues, and would be quite disturbed if they were missing and the outside world looked as though nothing unusual were happening.

1. Current Population Reports, op. cit., Table 2, p. 6.
2. N. Bosak, et al., Warning Systems Research Support: Concord Study, op. cit., passim.

PART FOUR: ESTIMATING INCREASED SURVIVORS

One of the primary goals of this project has been, in the words of the subcontract, to "Provide a basis for estimating increased survivors attributable to the optimum mixture under differing attack conditions." Although a great deal of effort has been applied to the task, the relationships between the work and this goal have not previously been cited and so identified. One purpose of Part Four is to define these relationships as succinctly as possible. The second purpose is to describe specific procedures (and examples) for making these data compatible with existing programs for estimating increased survivors.

Warning, whether optimum or otherwise, plays only a small role in the total civil defense effort to increase survivors of a nuclear attack. It fits into a complex of systems, facilities, ideas, and activities that begins with detection of an attack, and generally includes:

- Making the decision to warn.
- Distributing that decision to locations or points controlling warning.
- Disseminating the warning to the public (optimally).
- Publicly verifying the threat.
- Preparing to move to shelter.
- Traveling to shelter, avoiding hazards en route.
- Arriving at adequate shelter.
- Surviving in shelter.

While the role of warning the public is small, like the other activities it is vital to the mission of increasing survivors.

Deriving a measure of the effect on added survivors of any two or more of these elements can be (and has been) done in as many different ways as there are investigators interested in solving the problem. Because of the number of variables involved in the process, nearly all the recent investigations use computers to reduce the computational times to manageable levels.

Regardless of the level of sophistication used in approaching the problem, managing the variables, or quantifying the data, there are two indispensable bits of information associated with measuring the effect of warning systems: the numbers of people warned and the time required to warn them. The two can be expressed as relationships, distributions, or rates, and can take the form of curves, tables, graphs, or formulae. Frequently these data are elaborately derived and enhanced by complex compensating factors; sometimes they are simple, assumed values. It has not been possible to generate a serious estimate of increased survivors that considered warning without including these measures.

Obviously the measures of warning effectiveness described in Part Two provide the required basis for estimating increased survivors attributable to warning. It was not possible to determine the effectiveness of warning system combinations beyond the EBS/CHAT-TV combination and the generalized combination of the formal system and personal contacts. This limitation was due to the unknown overlapping coverage component which makes adding effectiveness measures impossible. The effect of this limitation has been to make estimates of increased survivors attributable to the optimum mixture equally unattainable. The data do allow such estimates for specific warning systems and for the particular EBS/CHAT-TV system combination.

In several ways the particular approach used in the project gives extra value to the goal of estimating increased survivors. Most notable is the provision of warning effectiveness standards. These standards can be used by those concerned with the end product of civil defense activities in many of the same ways

as they were used in studying the end product of the warning activity, that is, as a source of comparative values and standard of warning performance.

The identification of the number warned at 5-, 15-, and 30-minute intervals also provides an opportunity for detailed examination of warning effects by interpolating values within the range or extrapolating values beyond the upper limit. This kind of flexibility will be useful where the estimating procedures include integrating prewarning and postwarning behavior and time distributions with warning effectiveness measures.

Another feature of the Part Two warning effectiveness measures is the breakout of the contribution to effectiveness of each system element except for outdoor warning, where it was not possible to factor each out. This allows the more sophisticated estimating procedures to calculate the individual and combined effects of these elements on increased survivors.

The task of making these data compatible with existing increased survivors programs can be accomplished by using three general procedures: 1) updating the effectiveness estimates to the population/year base desired; 2) determining relevant summary measures of the 24-hour estimates; and 3) reformatting the data to program requirements. Each procedure is discussed below and an example based on the model of "warning effectiveness" devised by A. E. Moon[1] in 1965 is presented.

It should be observed that Moon's model measures neither warning effectiveness[2] (as it claims to) nor increased survivors (which it does not claim to measure).

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1. A. E. Moon, Population in Shelter: A Method For Measuring the Effectiveness of Radio Warning, Project No. MU-5071, Stanford Research Institute, Menlo Park, November 1965.
2. A more complete exposition of this point can be found in Gaydos, Miller, and Neilson, Measures of Warning Effectiveness, SDC TM-L-3390/003/01, 29 March 1968.

What it does provide are measures of the complete civil defense process--starting with threat detection and concluding with the fraction of population in shelter having received warning from particular sources. Included are appropriate graphs and work sheets so that the process can be repeated using different assumptions or parameters. The Moon model does not measure attack effects on the population (in or out of shelter), and thereby misses showing the number of survivors attributable to a particular feature of the civil defense process. However, the fact that it does illustrate the majority of factors used in systems designed to show survivors added, without using classified material, makes it most suitable to demonstrating the application of data in this report to survivors-added systems.

Throughout the previous discussion most of the population figures and other data were based on 1966 figures. The purpose of this was to use the latest common date for which full and complete information for the diverse topic areas investigated was available. Most programs for estimating increased survivors require data keyed to current and projected population measures. As might be expected, the measures of warning effectiveness are readily modified to reflect different population bases. The easiest method is to determine the ratio between the 1966 date and the new base year and use it as a corrective factor. For example, the Series A, 1975 Census projection is 228 million, or 116 percent of the 1966 census estimate. Thus, to adjust any of the effectiveness estimates to 1975 levels simply multiply the 1966 data by 116 percent.

Of course, the simple method is only useful if none of the factors used in computing the estimates are expected to be changed by the new base year. Generally speaking, most of these factors will remain reasonably constant. The only obvious changes will probably be to the metropolitan/nonmetropolitan populations and in the proportion of households with telephones. Also, continued investigation into the rates of dissemination would be useful, if only to monitor for changes and perhaps to learn more about crisis behavior. In any case, should there be a reason for wishing to modify any of the factors

used in our calculations, it can be easily accomplished and the estimates re-computed according to the description provided in the text. This will also allow modifying the assumptions used in the computations or making corrections as new information is made available. As it happens, updating beyond 1970 is not necessary for the Moon model example.

The second procedure is to determine appropriate summary measures. This procedure will only be required for programs unable to accommodate 24-hour data. As this seems to be the rule, it is probably useful to make some comments on the process. For the most part, independent investigators will wish to use summary measures best suited to their program requirements. However, the procedures used for Part Three of this study illustrate a relatively successful series of measures suited to the effectiveness estimates. Each of the significant variables (population coverage and time) was treated from the perspectives of magnitude and direction of change, regularity of differences and internal consistency. Whether the actual measures are used or not is less important than that each dimension is adequately covered in the analysis.

Since our sample case is the Moon model, the first variable of interest is population coverage for each of the warning systems. Time, at least in the sense of time requi ed to obtain various coverage values,is taken to be after 30-minutes; since there is at least 30-minutes before the arrival of the first fallout. Time can be accommodated in the sense that system coverage varies according to the hour of the day. Rather than use a single measure--as one of central tendency (the mean, median, or mode), the range is considered to provide the most suitable information for the Moon model. That is, we have selected the highest and lowest population coverage values (at 30 minutes) for each warning system. These are:

Warning Standards	84 million low (3 AM)	148 million high (8 PM)
EBS (Crisis)	90 million low (4 AM)	159 million high (7 PM)
EBS/CHAT-TV (Crisis)	111 million low (7 AM)	159 million high (7 PM)
Telephone System	124 million low (5 PM)	142 million high (9 PM)
Outdoor System	55 million low (3 AM)	85 million high (12 Noon)

The final procedure is reformatting the data to fit program requirements. As was the case for obtaining summary measures, the individual investigator will have his own ideas on the subject and will solve specific problems as he sees fit. However, as stated earlier, the effectiveness measures are readily adapted to many graphic and conceptual formatting schemes. For example, it would require very little effort to plot the 5-, 15-, and 30-minute measures on x, y coordinates to construct a series of warning effectiveness curves. If desired, the same data could be adapted to a percentage presentation scheme by computing the appropriate value from the population base. More sophisticated formats, such as fitting the data to distribution formulae or deriving generalized rates, can also be accomplished. For the Moon model example, it is first required that the data be converted from raw population values into proportions of the total population (i.e., percent). These are shown below:

Warning Standards	.43 low	.76 high
EBS	.46 low	.82 high
EBS/CHAT-TV	.57 low	.82 high
Telephone	.64 low	.73 high
Outdoor	.42 low	.63 high (metropolitan areas only)

These data can now be processed by the Moon model.

On the following pages are the worksheets for applying the effectiveness data derived in this study to the Moon model. Two sets of the worksheets are provided. The first set uses data for the period of lowest population coverage for each warning system. The second set uses data for the period of peak population coverage for each system. The two in conjunction could be used to estimate survivors added under different attack configurations--when classified data are available. To keep this example simple, certain values Moon allows to vary for each warning system were kept as constants throughout the computations. These are: system response time--5 minutes; fraction in shelter before fallout arrives--central city 86%, urban fringe 95%, nonurbanized areas 65%; and fallout

arrival times--central city and urban fringe 45 minutes, nonurbanized areas 75 minutes. It was believed that since Moon did not provide projection curves for the particular systems being tested, and since the sample is intended to demonstrate a set of procedures, little would be lost by using these constants. With the exceptions above and the necessity of making minor changes to the worksheets to eliminate Moon's references to other systems and to insert the appropriate system names, the computational process follows Moon's instructions exactly.[1]

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1. *Ibid.*, pp. 8-28.

MOON-MODEL

WORKSHEET FOR EVALUATING WARNING SYSTEM EFFECTIVENESS
DURING LOWEST POPULATION COVERAGE PERIOD

PART I. WARNING SYSTEM ENVIRONMENT

A. Time era 1970

B. Fallout arrival time computations

1. Time from detection of attack to impact of weapons 15 min.
2. Time from detection of attack to initiation of warning signal (decision to warn time) 0 min.
3. Remaining time from decision to impact (line 1 minus line 2) 15 min.

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
4. Time from impact to fallout arrival	30.0 min.	30.0 min.	60.0 min.
5. Time from decision to fallout arrival (line 3 plus line 4)	45 min.	45 min.	75 min.

PART II. WARNING SYSTEM EVALUATION SUMMARY - WORST CASE

(See following sheets for detailed evaluation of warning system modes. Listed below is a summary of the evaluation.)

WARNING SYSTEM MODE	FRACTION OF POPULATION IN SHELTER WHO WERE WARNED BY EACH MODE
A. Warning Standards	.35
B. EBS	.37
C. EBS/CHAT-TV	.47
D. Telephone Warning	.52
E. Outdoor-Siren Warning	.25

MOON-MODEL WORKSHEET (Continued)

PART III. DETAIL OF WARNING SYSTEM EVALUATION

A. WARNING STANDARDS

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
1. Time from decision to fallout arrival (from Part IB, line 5)	45 min.	45 min.	75 min.
2. System response time (time from decision to warn to beginning of alert signal)	5 min.	5 min.	5 min.
3. Time remaining to reach shelter (line 1 less line 2)	40 min.	40 min.	70 min.
4. Fraction in shelter before fallout arrives	.86	.95	.65
5. Population coverage by area	.43	.43	.43
6. Fraction of area populations in shelter as a result of the stimulus from warning (line 5 times line 4)	.37	.41	.28
7. Fraction of U.S. population residing in each area			
Existing	~~0.323~~	~~0.210~~	~~0.466~~
1970	0.333	0.324	0.343
Other			
(Cross out inapplicable line)			
8. Fraction of U.S. population in shelter in each area as a result of radio warning stimulus (line 7 times line 6)	.12	.13	.10
9. Fraction of U.S. population in shelter due to radio warning (sum of line 8, columns a, b, and c)		.35	

B. EBS

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
1. Time from decision to fallout arrival (from Part IB, line 5)	45 min.	45 min.	75 min.
2. System response time (time from decision to warn to beginning of alert signal)	5 min.	5 min.	5 min.
3. Time remaining to reach shelter (line 1 less line 2)	40 min.	40 min.	40 min.
4. Fraction in shelter before fallout arrives	.86	.95	.65
5. Population coverage by area	.46	.46	.46
6. Fraction of area populations in shelter as a result of the stimulus from alerting (line 5 times line 4)	.40	.44	.30
7. Fraction of U.S. population residing in each area			
Existing	~~0.323~~	~~0.212~~	~~0.465~~
1970	0.333	0.324	0.3'3
Other			
(Cross out inapplicable line)			
8. Fraction of U.S. population in shelter in each area as a result of alerting stimulus (line 7 times line 6)	.13	.14	10
9. Fraction of U.S. population in shelter due to alerting (sum of line 8, columns a, b, and c)		.37	

MOON-MODEL WORKSHEET (Continued)

PART III. DETAIL OF WARNING SYSTEM EVALUATION

C. EBS/CHAT-TV

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
1. Time from decision to fallout arrival (from Part IB, line 5)	45 min.	45 min.	75 min.
2. System response time (time from decision to warn to beginning of alert signal)	5 min.	5 min.	5 min.
3. Time remaining to reach shelter (line 1 less line 2)	40 min.	40 min.	70 min.
4. Fraction in shelter before fallout arrives	.86	.95	.65
5. Population coverage by area	.57	.57	.57
6. Fraction of area populations in shelter as a result of the stimulus from warning (line 5 times line 4)	.49	.54	.37
7. Fraction of U.S. population residing in each area			
Existing	~~0.393~~	~~0.212~~	~~0.465~~
1970	0.333	0.324	0.343
Other			
(Cross out inapplicable line)			
8. Fraction of U.S. population in shelter in each area as a result of radio warning stimulus (line 7 times line 6)	.16	.18	.13
9. Fraction of U.S. population in shelter due to radio warning (sum of line 8, columns a, b, and c)		.47	

D. TELEPHONE WARNING

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
1. Time from decision to fallout arrival (from Part IB, line 5)	45 min.	45 min.	75 min.
2. System response time (time from decision to warn to beginning of alert signal)	5 min.	5 min.	5 min.
3. Time remaining to reach shelter (line 1 less line 2)	40 min.	40 min.	70 min.
4. Fraction in shelter before fallout arrives	.86	.95	.65
5. Population coverage by area	.64	.64	.64
6. Fraction of area populations in shelter as a result of the stimulus from alerting (line 5 times line 4)	.55	.61	.42
7. Fraction of U.S. population residing in each area			
Existing	~~0.393~~	~~0.212~~	~~0.465~~
1970	0.333	0.324	0.343
Other			
(Cross out inapplicable line)			
8. Fraction of U.S. population in shelter in each area as a result of alerting stimulus (line 7 times line 6)	.18	.20	.14
9. Fraction of U.S. population in shelter due to alerting (sum of line 8, columns a, b, and c)		.52	

MOON-MODEL WORKSHEET (Concluded)

E. OUTDOOR-SIREN WARNING

		COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
1	Time from decision to fallout arrival (from Part 1B, line 5)	45 min.	45 min.	N/A min.
2.	System response time (time from decision to warn to beginning of alert signal)	5 min.	5 min.	min.
3.	Time remaining to reach shelter (line 1 less line 2)	40 min.	40 min.	min.
4.	Siren Effectiveness Group (see chart below)			

		Radio Support for Sirens: Existing	Radio Support for Sirens: Close
Public Readiness	LO	I	II
	HI	III	IV

		COLUMN a	COLUMN b	COLUMN c
5.	Fraction of siren-alerted populations in shelter before fallout arrival (select siren alerting chart for proper time era, enter chart with time from 3, above, determine fraction corresponding to siren effectiveness group)	.56	.95	N/A
6.	Indoor siren coverage (fraction of population that can hear sirens indoors, by area)	.42	.42	
7.	Fraction of area populations in shelter as a result of the stimulus from siren alerting (line 6 times line 5)	.36	.40	
8.	Fraction of U.S. population residing in each area			
	Existing	~~0.323~~	~~0.212~~	0.465
	1970	0.333	0.324	0.343
	Other (Cross out inapplicable line)			
9.	Fraction of U.S. population in shelter in each area as a result of siren alerting stimulus (line 8 times line 7)	.12	.13	
10.	Fraction of U.S. population in shelter due to siren alerting (sum of line 9, columns a, b, and c)		.25	

MOON-MODEL

WORKSHEET FOR EVALUATING WARNING SYSTEM EFFECTIVENESS DURING PEAK POPULATION COVERAGE PERIOD

PART I. WARNING SYSTEM ENVIRONMENT

A. Time era 1970

B. Fallout arrival time computations

1. Time from detection of attack to impact of weapons 15 min.
2. Time from detection of attack to initiation of warning signal (decision to warn time) 0 min.
3. Remaining time from decision to impact (line 1 minus line 2) 15 min.

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
4. Time from impact to fallout arrival	30.0 min.	30.0 min.	60.0 min.
5. Time from decision to fallout arrival (line 3 plus line 4)	45 min.	45 min.	75 min.

PART II. WARNING SYSTEM EVALUATION SUMMARY - BEST CASE

(See following sheets for detailed evaluation of warning system modes. Listed below is a summary of the evaluation.)

WARNING SYSTEM MODE	FRACTION OF POPULATION IN SHELTER WHO WERE WARNED BY EACH MODE
A. Warning Standards	.62
B. EBS	.67
C. EBS/CHAT-TV	.67
D. Telephone Warning	.59
E. Outdoor-Siren Warning	.37

MOON-MODEL WORKSHEET (Continued)

PART III. DETAIL OF WARNING SYSTEM EVALUATION

A. WARNING STANDARDS

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
1. Time from decision to fallout arrival (from Part IB, line 5)	45 min.	45 min.	75 min.
2. System response time (time from decision to warn to beginning of alert signal)	5 min.	5 min.	5 min.
3. Time remaining to reach shelter (line 1 less line 2)	40 min.	40 min.	70 min.
4. Fraction in shelter before fallout arrives	.86	.95	.65
5. Population coverage by area	.76	.76	.76
6. Fraction of area populations in shelter as a result of the stimulus from warning (line 5 times line 4)	.65	.72	.49
7. Fraction of U.S. population residing in each area			
Existing	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
1970	0.333	0.324	0.343
Other			
(Cross out inapplicable line)			
8. Fraction of U.S. population in shelter in each area as a result of radio warning stimulus (line 7 times line 6)	.22	.23	.17
9. Fraction of U.S. population in shelter due to radio warning (sum of line 8, columns a, b, and c)		.62	

B. EBS

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
1. Time from decision to fallout arrival (from Part IB, line 5)	45 min.	45 min.	75 min.
2. System response time (time from decision to warn to beginning of alert signal)	5 min.	5 min.	5 min.
3. Time remaining to reach shelter (line 1 less line 2)	40 min.	40 min.	70 min
4. Fraction in shelter before fallout arrives	.86	.95	.65
5. Population coverage by area	.82	.82	.82
6. Fraction of area populations in shelter as a result of the stimulus from alerting (line 5 times line 4)	.71	.78	.53
7. Fraction of U.S. population residing in each area			
Existing	~~0.303~~	~~[illegible]~~	~~[illegible]~~
1970	0 333	0 324	0 313
Other			
(Cross out inapplicable line)			
8. Fraction of U.S. population in shelter in each area as a result of alerting stimulus (line 7 times line 6)	.24	.25	.18
9. Fraction of U.S. population in shelter due to alerting (sum of line 8, columns a, b, and c)		.67	

MOON-MODEL WORKSHEET (Continued)

PART III. DETAIL OF WARNING SYSTEM EVALUATION

C. EBS/CHAT-TV

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
1. Time from decision to fallout arrival (from Part IB, line 5)	45 min.	45 min.	75 min.
2. System response time (time from decision to warn to beginning of alert signal)	5 min.	5 min.	5 min.
3. Time remaining to reach shelter (line 1 less line 2)	40 min.	40 min.	70 min.
4. Fraction in shelter before fallout arrives	.86	.95	.65
5. Population coverage by area	.82	.82	.82
6. Fraction of area populations in shelter as a result of the stimulus from warning (line 5 times line 4)	.71	.78	.53
7. Fraction of U.S. population residing in each area			
Existing	~~0.333~~	~~0.212~~	~~0.465~~
1970	0.333	0.324	0.343
Other			
(Cross out inapplicable line)			
8. Fraction of U.S. population in shelter in each area as a result of radio warning stimulus (line 7 times line 6)	.24	.25	.18
9. Fraction of U.S. population in shelter due to radio warning (sum of line 8, columns a, b, and c)		.67	

D. TELEPHONE WARNING

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
1. Time from decision to fallout arrival (from Part IB, line 5)	45 min.	45 min.	75 min.
2. System response time (time from decision to warn to beginning of alert signal)	5 min.	5 min.	5 min.
3. Time remaining to reach shelter (line 1 less line 2)	40 min.	40 min.	70 min.
4. Fraction in shelter before fallout arrives	.86	.95	.65
5. Population coverage by area	.73	.73	.73
6. Fraction of area populations in shelter as a result of the stimulus from alerting (line 5 times line 4)	.63	.69	.47
7. Fraction of U.S. population residing in each area			
Existing	~~0.333~~	~~0.212~~	~~0.465~~
1970	0.333	0.324	0.343
Other			
(Cross out inapplicable line)			
8. Fraction of U.S. population in shelter in each area as a result of alerting stimulus (line 7 times line 6)	.21	.22	.16
9. Fraction of U.S. population in shelter due to alerting (sum of line 8, columns a, b, and c)		.59	

MOON-MODEL WORKSHEET (Concluded)

B. OUTDOOR-SIREN ALERTING

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
1. Time from decision to fallout arrival (from Part IB, line 5)	45 min.	45 min.	N/A min.
2. System response time (time from decision to warn to beginning of alert signal)	5 min.	5 min.	min.
3. Time remaining to reach shelter (line 1 less line 2)	40 min.	40 min.	min.
4. Siren Effectiveness Group (see chart below)			

		Radio Support for Sirens: Existing	Radio Support for Sirens: Close
Public Readiness	LO	I	II
	HI	III	IV

	COLUMN a CENTRAL CITY AREAS	COLUMN b URBAN FRINGE AREAS	COLUMN c NONURBANIZED AREAS
5. Fraction of siren-alerted populations in shelter before fallout arrival (select siren alerting chart for proper time era, enter chart with time from 3, above, determine fraction corresponding to siren effectiveness group)	.86	.95	N/A
6. Indoor siren coverage (fraction of population that can hear sirens indoors, by area)	.63	.63	
7. Fraction of area populations in shelter as a result of the stimulus from siren alerting (line 6 times line 5)	.54	.60	
8. Fraction of U.S. population residing in each area			
Existing	~~0.323~~	~~0.212~~	0.465
1970	0.333	0.324	0.343
Other			
(Cross out inapplicable line)			
9. Fraction of U.S. population in shelter in each area as a result of siren alerting stimulus (line 8 times line 7)	.18	.19	
10. Fraction of U.S. population in shelter due to siren alerting (sum of line 9, columns a, b, and c)		.37	

APPENDIX

This appendix contains tables prepared for and used in the course of work on the project, but which are supplemental to the text proper. If they were simply "working papers", it would be easy to leave them out. However, they constitute either a particularly concise summary of data or information not described elsewhere in the report.

Tables A-1, A-2, and A-3 are summary tables; presenting the 5-, 15-, and 30-minute warning effectiveness estimates and the hourly contributions of each warning element. Tables A-4, A-5, and A-6 are similar to the preceding ones except the values have been revised to reflect metropolitan areas. The last one, Table A-7, represents the warning capability of OCD-funded sirens in metropolitan areas.

Table A-1. Initial Receipt by Population (in Millions) of High Saliency News within 5 Minutes - by Source and for Total

TIME	RADIO	TV	TELEPHONE	FACE-TO-FACE	TOTAL
1 AM	1	6	7	21	35
2	1	3	7	22	33
3	X	X	8	23	31
4	X	X	8	23	31
5	X	X	8	23	31
6	9	-	7	20	36
7	16	3	6	17	42
8	16	8	5	16	45
9	16	12	5	15	48
10	15	14	5	15	49
11	14	16	5	15	50
12	13	18	5	14	50
1 PM	12	20	5	14	51
2	11	20	5	15	51
3	11	22	5	14	52
4	12	23	5	14	54
5	12	25	4	13	54
6	12	32	4	12	60
7	11	39	3	10	63
8	9	46	3	9	67
9	8	49	3	8	68
10	7	46	3	9	65
11	6	35	4	12	57
12	3	16	6	18	43

Source:

Based on data in Table 1-4.

Table A-2. Initial Receipt by Population (in Millions) of High Saliency News within 15 Minutes - by Source and for Total

TIME	RADIO	TV	TELEPHONE	FACE-TO-FACE	TOTAL
1 AM	1	10	9	28	48
2	1	5	9	29	44
3	X	X	10	31	41
4	X	X	10	31	41
5	X	X	10	31	41
6	12	-	9	27	48
7	22	5	7	23	57
8	22	12	6	21	61
9	22	9	6	20	67
10	20	22	6	20	68
11	19	25	6	20	70
12	17	19	6	19	61
1 PM	16	31	6	19	72
2	15	32	6	20	73
3	15	35	6	19	75
4	16	36	6	19	77
5	16	40	5	17	78
6	16	50	5	16	87
7	15	62	4	13	94
8	12	73	4	12	101
9	11	78	4	11	104
10	10	73	4	12	99
11	8	55	5	16	84
12	4	26	8	24	62

Source:

Based on data in Table 1-4.

Table A-3. Initial Receipt by Population (in Millions) of High Saliency News within 30 Minutes - by Source and for Total

TIME	RADIO	TV	TELEPHONE	FACE-TO-FACE	TOTAL
1 AM	2	13	16	60	91
2	2	6	16	62	86
3	X	X	18	66	84
4	X	X	18	66	84
5	X	X	18	66	84
6	21	-	16	57	94
7	38	6	13	48	105
8	42	15	11	45	113
9	38	25	11	42	116
10	35	28	11	42	116
11	33	33	11	42	119
12	30	37	11	41	119
1 PM	30	40	11	41	122
2	26	32	11	42	111
3	26	43	11	40	120
4	28	46	11	39	124
5	28	51	9	36	124
6	28	64	9	33	134
7	25	79	7	28	139
8	21	93	7	27	148
9	19	99	7	23	148
10	17	93	7	26	143
11	14	65	9	35	123
12	7	33	14	52	106

Source:

Based on data in Table 1-4.

Table A-4. Initial Receipt by Population (in Millions) of High Saliency News within 5 Minutes - by Source for Metropolitan Areas

TIME	RADIO	TV	TELEPHONE	FACE-TO-FACE	TOTAL
1 AM	1	4	5	14	23
2	1	2	5	14	21
3	X	X	5	15	20
4	X	X	5	15	20
5	X	X	5	15	20
6	6	-	5	13	23
7	12	2	4	11	27
8	10	5	3	10	29
9	10	8	3	10	31
10	10	9	3	10	32
11	9	10	3	10	32
12	8	12	3	9	32
1 PM	8	13	3	9	33
2	7	13	3	10	33
3	7	14	3	9	34
4	8	15	3	9	35
5	8	16	3	8	35
6	8	21	3	8	39
7	7	25	2	6	41
8	6	30	2	6	43
9	5	32	2	5	49
10	5	30	2	6	42
11	4	23	3	8	37
12	2	10	4	12	28

Source:

Based on data in Table 1-4.

Table A-5. Initial Receipt by Population (in Millions of high Saliency News within 15 Minutes - by Source for Metropolitan Areas

TIME	RADIO	TV	TELEPHONE	FACE-TO-FACE	TOTAL
1 AM	1	6	6	18	31
2	1	3	6	19	28
3	X	X	6	20	26
4	X	X	6	20	26
5	X	X	6	20	26
6	8	-	6	17	31
7	14	3	5	15	37
8	14	8	4	14	39
9	14	6	4	13	43
10	13	14	4	13	44
11	12	16	4	13	45
12	11	12	4	12	39
1 PM	10	20	4	12	46
2	10	21	4	13	47
3	10	23	4	12	48
4	11	23	4	12	50
5	11	26	3	11	50
6	11	32	3	11	56
7	10	40	3	8	61
8	8	47	3	8	65
9	7	50	3	7	67
10	6	47	3	8	64
11	5	35	3	10	54
12	3	17	5	15	40

Source:

Based on data in Table 1-4.

Table A-6. Initial Receipt by Population (in Millions) of High Saliency News within 30 Minutes - by Source for Metropolitan Areas

TIME	RADIO	TV	TELEPHONE	FACE-TO-FACE	TOTAL
1 AM	1	8	10	39	59
2	1	4	10	40	55
3	X	X	12	43	54
4	X	X	12	43	54
5	X	X	12	43	54
6	14	-	10	37	61
7	25	4	8	31	68
8	27	10	7	29	73
9	25	16	7	27	75
10	23	18	7	27	75
11	21	21	7	27	77
12	19	24	7	26	77
1 PM	19	26	7	26	79
2	17	21	7	27	72
3	17	28	7	26	77
4	18	30	7	25	80
5	18	33	6	23	80
6	18	41	6	21	86
7	16	51	5	18	90
8	14	60	5	17	95
9	12	64	5	15	95
10	11	60	5	17	92
11	9	42	6	23	79
12	5	21	9	34	68

Source:

Based on data in Table 1-4.

Table A-7. Theoretical Minimum Alerting Capability of OCD Funded Sirens in Metropolitan Areas - Millions Alerted for Period Indicated

TIME	POPULATION IN METROPOLITAN AREAS	ALERTED 0-5 Min	ALERTED 0-15 Min	ALERTED 0-30 Min
1 AM	126	-	11	14
2	126	-	10	14
3	126	-	9	13
4	126	-	8	13
5	126	-	10	14
6	126	-	10	14
7	126	-	11	15
8	123	2	11	16
9	127	3	14	17
10	129	3	13	17
11	129	5	14	18
12	129	6	17	20
1 PM	129	5	16	19
2	129	5	16	19
3	128	5	15	18
4	128	4	15	19
5	126	4	14	18
6	122	4	13	18
7	122	4	13	18
8	122	4	14	18
9	123	4	14	18
10	123	3	13	17
11	123	2	12	16
12	123	1	11	15

Source:

Uses 15 percent estimate of OCD funded siren coverage and adjustments for hourly variations due to noise, sleep and outdoor density.

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13. ABSTRACT

This document is the final report of the Local Warning System Definition project performed for the Stanford Research Institute under Subcontract SRI 12675 (6300A-680). The report describes a method for determining an optimum mixture of public warning systems. Two types of input data to the optimum mixture method are developed: warning effectiveness standards based on empirically determined news dissemination rates and broadcasting industry audience figures, and measures of particular systems' coverage and speed of dissemination--or system effectiveness. In addition to two versions of the warning effectivness standards, outdoor warning, EBS (crisis), EBS with CHAT-TV and a telephone warning system are used in a first test of the method. Use of the optimum mixture in programs for estimating increased survivors is also described.

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EBS						
Crisis Home Alert Technique						
CHAT						
Telephone Warning System						

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